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MEMOIRS OF THE GEOLOGICAL SURVEY.

SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN.

VOL. XXVI.—LEAD AND ZINC ORES OF DURHAM, YORKSHIRE AND DERBYSHIRE, WITH NOTES ON THE ISLE OF MAN.

BY R. G. CARRUTHERS
AND
SIR AUBREY STRAHAN, K.B.E., F.R.S.

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PREFACE.

In this report the lead mines of Teesdale, Weardale and Swaledale are described together with those of Derbyshire and certain other districts of minor importance. These have all been centres of great activity in lead-mining in the past and though at present the industry is in a depressed condition there may possibly be a long future of mining in those parts of the area where the circumstances are favourable. During the war this was one of the principal British sources of lead ore.

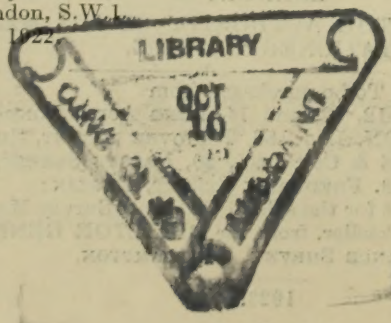
The memoir as a whole has been edited by Mr. Carruthers, who is responsible for its general form and for the treatment of the subject. He has found that Sir Aubrey Strahan's account of the lead and zinc deposits of Derbyshire, which was published in the Geological Survey Memoir on the Carboniferous Limestone, etc., of North Derbyshire (Second Edition, 1887), is still the best and most complete description of that district; most of the parts of that memoir relating to our subject have been reprinted here with alterations and additions by Mr. Carruthers where necessary to bring the information up to date. Sir Aubrey Strahan desires in turn to express his indebtedness to the work of A. H. Green, J. R. Dakyns and C. le Neve Foster, who were the authors of the first edition of the memoir referred to.

A few notes have been added by Mr. Lamplugh on the lead and zinc mines in the Isle of Man. These are supplementary to the economic chapters of his memoir 'The Geology of the Isle of Man,' which are also published in separate form and have not been reprinted as a sufficient number of copies to meet the demand for several years is still unsold.

Mr. Carruthers desires to thank the officials of the mining companies in the districts he investigated for the great courtesy with which they responded to his enquiries and placed their information at his service. In particular he is indebted to Mr. H. S. Willis, the late Mr. Watson and Mr. Madison of the Weardale Lead Co.; Mr. R. W. Raine, Middleton-in-Teesdale; Mr. Surtees, Raby Estate Office; Mr. Robinson of the Long Fell Barytes Company; Mr. Reynoldson, Brough-under-Stainmore; Mr. W. Varvill, Greenhow; Mr. G. Garlick, Lynx Works, Sheffield; Mr. G. Eagle, and Mr. Hugh Seed of the Ashover Mines. Professor P. F. Kendall of Leeds University has also been of much assistance in reference to the mines of the Grassington district.

JOHN S. FLETT,
Director.

Geological Survey Office,
28, Jermyn Street,
London, S.W.1.
17th May, 1922.



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LEAD AND ZINC ORES

OF

DURHAM, YORKSHIRE AND DERBYSHIRE,

WITH NOTES ON THE

ISLE OF MAN.

CHAPTER I.

INTRODUCTION.

The lead-mining fields of the central and southern Pennines have already been referred to in the preceding volume,* where their leading characteristics and relations to other areas were noted. They are all in Lower Carboniferous strata, traversed by fissure veins of normal type, which are, in Derbyshire especially, often accompanied by ' chamber-deposits ' : in Weardale there are valuable ore-bodies of metasomatic origin, peculiar to that district.

The chief ore is galena, blende being very subordinate, and sporadically distributed : cerussite and other ' oxidation ' minerals mainly came from high levels in the mines, now wrought out.

The gangue spars are often curiously localised, fluorspar prevailing in Weardale, for instance, while a few miles to the south, in an identical ' country-rock,' it gives place to calcite or barytes almost entirely.

In the dales of North-West Yorkshire and Durham, with their variety of sediments, the possibility of the ore-bodies being affected by the ' country-rock ' becomes of great importance : the question obviously has a direct bearing on the desirability of further explorations in depth. One finds that each district has its favourite horizon, which may be relatively barren in a neighbouring field. Though limestone is generally a favourable subject, that appears to be so merely because it is a rock where fissures are readily enlarged by water, and can then carry large bodies of ore : in depth the productivity dies away, as it does in other sediments. Illustrations of this are sufficiently common, and amongst them Teesdale may be cited ; the sediments here dip gently towards the east, and at the head of the dale the lowest Yoredale limestones, (the Tynebottom and Jew Limestones) outcrop and are productive. Further down the valley the Great Limestone appears and at its outcrop gave much ore, but still further east proved useless in depth, ore then being got from sandstones (the Firestone Sill, &c.) and from the Millstone Grit

* Special Reports on the Mineral Resources of Great Britain, Vol. xxv.—Lead and Zinc Ores of Northumberland and Alston Moor. *Mem. Geol. Surv.*, 1923.

above. Much of the same happens elsewhere, and in fact, were the Pennines a virgin region, one would say that proximity to the surface, rather than rock-type, was the paramount consideration for a rich 'country.' In many fields (*e.g.*, in Swaledale and in mid-Teesdale) another favouring condition is a high altitude, the productive zone being more or less horizontal, and completely cut through by the existing valley systems : the whole of the ore can then be extracted from adit levels, and at the valley bottoms the veins turn barren. From these facts one infers that the mineralisation took place after the major crustal movements had ceased, but before the present topography was initiated : in all probability it is of late Carboniferous or Triassic date.*

The foregoing considerations all militate against the hope of getting further extensions of the lead-fields in depth. Nevertheless the area as a whole still heads the list of home producers of galena, owing to the continuous output from the metasomatic ore-bodies at Boltsburn, and from the 'chamber-deposits' of the Millclose Mine. The recrudescence of activity in the old mining field of Greenhow, near Pateley Bridge, shows that it is still possible to find ore in ground which has been much worked over in the past, but this case is exceptional, in that the driving of a deep-level waterworks tunnel gave definite proof that the ore persisted in depth. As has been seen, the reverse generally happens, and although one or two localities are indicated where payable ore-bodies should still be got, any considerable revival of the industry seems hardly possible.

DETAILED DESCRIPTIONS OF THE MINES.

WEARDALE.

General Account.

Lead ore has been raised for many centuries in Weardale, possibly even since Roman times†, and work is still in active progress. Though the output has been much curtailed, considerable reserves are still intact, and the district is now the chief lead-mining centre in the North of England : since 1883 practically all the operations have been in the hands of a single firm, the Weardale Lead Company.

Geology.—The Lower Carboniferous 'Lead Measures' of Weardale, like those of the adjacent Alston Moor field, comprise sandstone ('hazle sills') shales ('plate') and limestones, with a few

* For other evidence see *loc. supra cit.* p. 5. Some valuable observations by Mr. Stephen Watson in a paper on 'Recent Mineral Deposits' (*Trans. Weardale Nat. Field Club* vol. i, part i, pp. 57–61) show that a re-distribution of the contents of some of the veins is in process at the present time

† Mining was certainly established by 1135, the earliest record definitely known : a most interesting historical account of the region has been given by Professor Louis in his paper on 'Lead Mines in Weardale, County Durham' (*Mining Magazine*, Jan. 1917).

thin seams of coal and fire clay. The vast majority of these strata are of Yoredale age (Upper Carboniferous Limestone) but on the highest ground outliers of Millstone Grit are occasionally found.

In the lower part of the sequence there is a sheet of intrusive dolerite, the Great Whin Sill; a subsidiary intrusion appears on either side of the river above Stanhope, on a somewhat higher level.

The whole sequence of workable measures is similar to that in the Allendales: it amounts to about 700 ft., and inclines towards the north-east, but so gently as to appear almost horizontal over large areas.

The hillsides of this typical upland dale are comparatively free from drift, and one can readily follow the harder beds of sandstone and limestone winding in and out of the tributary stream valleys. The only dislocation of any size is the Burtree Ford Dyke, a somewhat ill-defined line of disturbance in the upper part of the dale: this runs N.N.E. through Cows Hill, with a maximum upthrow west of nearly 500 ft.,* but dies out rapidly both to the north and south: it is not mineralised.

The metalliferous veins are of the fissure type, most of them being associated with small normal faults of a few feet throw: they have a general trend N.E. or E., only a few going N. or N.W. They are essentially galena-fluorspar veins, frequently rich in iron carbonates in their upper levels, above the 'oxidation zone.' Curiously enough, blende, though so plentiful in the neighbouring mineral fields of Allendale and the Nent Valley (Alston Moor), is rare in Weardale, and has only been got in commercial quantity in one or two veins round Killhope, close to the western watershed. Small amounts of quartz and calcite are often found in the gangue, but only the merest trace of any copper ore.

In the early days of mining some amount of cerussite, and a highly argentiferous galena, were got, besides large quantities of iron carbonate: a natural result, since the workings then lay above water-level, and were within the oxidation zone. Nowadays, the mines are below adit-level, and galena is the only lead-ore obtained: it yields about 5 ozs. of silver per ton of silver-lead, a quantity common to all the veins, and unaffected by depth.

The lodes bear well in the harder beds, that is, in the sandstones and limestones; in the shales they are almost always poor, a result probably due to the general flattening and consequent closing in of fault planes when traversing shales (see the section of Wolfcleugh Veins, Fig. 1).

---

* Strictly speaking, the Dyke is an anticline with a steep eastern limb: in the core of the fold, at Copt Hill, the Tynebottom Limestone is seen in the river bed, below the Whin Sill, and for nearly 300 yds. downstream there is an average dip S.E. of 35°, flattening out again about the Four Fathom Limestone position at Burtree Ford: altogether some 500 ft. of strata are involved.

The richest horizon is the Great Limestone, which, both here and at Alston Moor, is said to have produced more ore than all the other strata together. No doubt this is largely because it is the thickest limestone in the sequence, and would therefore have the most extensive cavities and fissures where ore-depositions could take place. There is an additional reason, however, which has assumed paramount importance during the last 50 years : very large galena bodies, due to metasomatic replacement, have been discovered in this limestone at the Boltsburn Mine, and now provide almost the whole output from the dale : a detailed account of them will be found in the description of that mine (p. 10). Similar ' flats,' as they are termed locally, had previously been found, though on a much smaller scale, at Greenlaws and Killhope, and they are a striking feature in the adjacent Alston Moor fields, where also they chiefly occur in the Great Limestone. These replacement ore-bodies have several features in common, as detailed below :—

1.—Restriction to limestone horizons (generally the Great Limestone).

2.—Association with one or more veins, which have evidently acted as feeders.

3.—The size or value of the ' flat ' has no relation to that of the feeding vein, and may be separated from it by a barren zone of close-grained ferruginous dolomite (' rider ') through which connection is maintained by occasional veinlets of ore (' live strings ').

4.—Dolomitisation of all limestone still remaining within the replacement area.

Killhope Mines.

Around Killhope, at the head of Weardale, several short N.E. veins outcrop in the Great Limestone and overlying strata. At least five of them were drained by the Park level, a cross-cut driven W. 16° N. for 950 yds., starting from the right bank of the Killhope Burn 1 m. above its junction with Wellhope Burn. On re-opening the mine some years ago it was seen that little had been left even below adit level : the *Middle Groove Vein* was the best, but the prospects did not warrant a resumption of the working.

Further west, near the bridge at the foot of Killhope Bank, the stream is crossed by the Killhopehead Vein, running N.E. up the hillsides on either hand for about 1 m., and having a downthrow S.E. of 4 ft. This vein was very productive in the higher levels (from the Firestone Sill on to the Great Limestone) but died out rapidly in depth : it split up and pinched out altogether in the Four-Fathom Limestone.

No ' flats ' were got in any of these Killhope veins, but valuable ore-bodies of this type were associated with the Cowhorse (or

Cowhaust) Vein, which runs E. 10° N. from Cowhorse Hill down to Killhope Burn : these were found in the Great Limestone, and were the mainstay of the mine, as the vein itself was useless.

Westgarth Forster, writing in 1809, states that the Killhope Mines were then producing blende as well as galena. Commercial quantities of this mineral do not seem to have been got anywhere else in Weardale, notwithstanding that it is so abundant in the adjacent Nent Valley, and over the Alston Moor regions generally.

Bracken Sike Vein.*

The Bracken Sike Vein can be followed from Cows Hill N. 10° E., up Burtree Fell for 1½ m. The lode was along a fault down W. from 4 to 6 ft., and is marked by many old shafts and opencasts up the hillside. The workings stopped half-a-century ago, and little is now known about them : the mine was evidently a rich one, and in one year alone (1809) is stated by Westgarth Forster to have yielded 4,000 tons of ore. The strata above adit level range from the Grindstone Sill down to the Four-Fathom Limestone.

Burtree Pasture Mine.

The Burtree Pasture Vein runs about 60 yds. E. of, and parallel to, the Bracken Sike Vein for about half-a-mile N. of Cows Hill, and then turns N.E. over Sedling Fell into Rookhope, a distance of nearly 2½ miles in all. It may be regarded as a branch from the strong line of disturbance known as the Burtree Ford Dyke, and is associated with a fault 6 or 7 ft. down N., increasing near the Dyke to 33 ft. The lode was generally from 6 to 9 ft. wide, and carried galena mixed with fluorspar, and occasionally concentrated in the centre of the vein.

The mine was for long the most extensive in Weardale : it yielded great quantities of ore during the last century, but was closed down 35 years ago. On the highest ground the vein traversed Millstone Grit, and ore was got from all levels below this down to the Tynebottom Limestone, underneath the Whin Sill. Some of the upper horizons were unusually productive, especially at the Firestone position.

The Whin Sill was proved 40 fathoms thick in this mine, a maximum for the district : it carried some ore, but was ' pockety.' The workings here were 130 fathoms below adit level and the vein began to narrow rapidly, although no change was observed in the nature or proportions of its constituent minerals. The workings eventually got down under the igneous rock and into the Tynebottom Limestone, but this proved unproductive ; as explorations

* This should not be confused with the smaller working in Rookhope termed Brecken Sike on the Ordnance Survey maps, and really a continuation of the Burtree Pasture Lode.

along the eastern range of the lode, in Rookhope, showed that it split up and dwindled in that direction, all work was suspended in 1887. The mine has never been re-opened, and is now thought to be exhausted: it is said that the deep workings, though not heavily watered, were difficult to ventilate.

Sedling Vein.

This important lode branches off from the Burtree Ford Dyke, about ¼ m. N. of Cows Hill, running E. and E. by S., towards Middlehope for nearly two miles. Associated with it was a small fault down N. from 2 to 6 fathoms, the vein itself being 6 to 12 ft. wide: shattered 'country rock' along its course may be seen in the deep 'hush' E. of Sedling Burn.

Most of the galena was concentrated on the N. side of the vein, the rest being fluorspar. The ore was taken out long ago (or, in local parlance, the vein was 'slit by the old man') right along the vein, but as the fluor was left behind, mining is still carried on for this spar, along with such small quantities of galena as it may contain: in 1917, 24 tons of dressed ore were so recovered, and in 1918, 8 tons.

The vein is useless in depth, having been tried down to the Scar Limestone without result.

Slitt Vein.

This lode can be followed for over 6 miles from Wearhea E. and S.E. across Middlehope and over the River Wear at Cammock Isles as far as Billing Hills (¾m. S.S.W. from Eastgate). The higher levels carried much iron ore, particularly E. of the Middlehope Burn, where broken vein-rock impregnated with oxide and carbonate of iron is well seen in the great opencasts at West Rigg Mine. Under these iron deposits, galena appeared in force, and was extensively wrought at the Slitt Mine, alongside the Middlehope Burn above Westgate: here there were levels driven westwards in the Great Limestone, and a shaft 100 fathoms deep, which pierced the Whin Sill, 26 fathoms thick: the lode closed in and was useless below the upper part of the sill.

There is a small working for fluorspar by the riverside at Cammock Isles, but, apart from this, nothing was done on the vein for the last 50 years, and so far as the N. side of the river is concerned, it is believed to be exhausted.

On the north side of the river, above St. John's Chapel, the *Old Fall* and *Lodgefield Veins* branch off in a S.W. direction from Slitt Vein: some abortive trials have been made on these lodes within comparatively recent years. In 1896 Old Fall Mine was re-opened and explored, after lying idle 50 years, and three years later the shaft was carried down to 150 ft., but the vein proved to be only 2 ft. wide, and is now regarded as useless either for galena or fluorspar.

Greenlaws Mines.

The workings on East and West Greenlaws Veins were at one time among the most important in Weardale, but they have now been abandoned for twenty years. These two lodes lie S. of St. John's Chapel, trending in a general S.W. direction towards the Weardale-Teesdale watershed: they traverse strata ranging from the Felltop Limestone down to the Scar Limestone, all horizontal or with but a very gentle rise towards the south.

Greenlaw's East Vein is on a fault from 4 to 6 ft. down N.E., and in the workings was from 6 to 9 ft. wide, ore-bearing throughout. There were three main levels: the lowest, or Quarry Level, started from Pinfoldhouse Quarry, 270 yds. S. of Daddry Shield, in sandstone under the Five Yards Limestone. It was driven S. 25° E. for 600 yds. until it cut the vein in the Scar Limestone N.E. of High Wood Meadows, good 'flats' being found in the limestone there. The Middle Level was on the S. bank of Daddry Shield Burn, nearly $\frac{3}{4}$ m. from St. John's Chapel, and was driven under the Four Fathom Limestone: a shaft was sunk on the vein hereabouts to a depth of 500 ft. below surface, through the Tynebottom Limestone on to the Whin Sill, but at that depth the vein was both poor and thin, and had to be abandoned. Watt's Level began under the Great Limestone further upstream, and led S. 20° W. for 400 yds. till it cut the lode; it then turned S. 20° E., in which direction it was carried forward for 800 yds. as a trial cross-cut, but without result. A branch of Watt's Level was driven along the vein for nearly a mile up to the watershed, and proved most productive: trial cross-cuts were sent out on either side, and the upper reaches of the vein wrought from a fourth opening, known as the Firestone Level.

The vein as a whole was productive at all levels, but especially in limestone strata. Besides the 'flats' in the Scar Limestone at High Wood Meadows, others were got on either side of the vein in the Great Limestone. According to the description furnished by the late Mr. Watson, of the Weardale Lead Coy., the Great Limestone 'flats' appear to have been metasomatic replacements similar to those at Boltsburn, though not so rich: the best ore-bodies lay away from the veins, from which they were at times as much as 40 yds. distant.

Greenlaws West Vein runs S.W. from Daddry Shield, ending round the head-waters of Harthope Burn. The bottom level (Dent's) started on the left bank of Daddry Shield Burn, directly opposite the mouth of the Quarry Level cross-cut to the East Vein: it entered West Vein within 100 yds., and the course of the old workings can be followed by a continuous succession of old shafts towards Harthope. Other levels on the vein were driven in from the Great Limestone outcrop at Greenlaws Mine, and there was a cross-cut starting below the Firestone Sill at Harthope Old Mine, beyond which the lode apparently dies out.

The vein ran along a fault, down N.W. 4 ft; it does not seem to have been so rich as the East Vein, and there do not seem to have been any ' flats ' noticed where it traversed limestone strata.

Veins in the Rookhope Valley.

The tributary valley of Rookhope, north of the River Wear above Westgate, contains several south-westerly lodes, including the one with which the famous Boltsburn deposits are associated. In the upper part of the valley a continuation of the Burtree Pasture lode, here known as the Bracken Sike Vein, has already been noted. About half-a-mile S.E. of this there is the *Wolfcleugh Old Vein*, which was an important producer of lead-ore throughout the last century, and although no longer in work, is thought to be not yet exhausted. The vein runs S.W., crossing the Rookhope Burn nearly $2\frac{1}{2}$ miles above Boltsburn village : down by the stream it cuts the Firestone Sill, and leading up the hillside to the S.W. for about a mile it rises up to the Felltop Limestone. The mine workings were re-opened in 1901, and wrought on either side of Rookhope Burn from a 40-fathom shaft sunk to the Quarry Hazle, with staples and drifts for a further 15 fathoms, down to the Nattrass Gill Hazle* (*see* fig. 1). Ore continued to be raised for some years, the best yield coming from the Great Limestone south of the Burn : the deeper levels, about the Four Fathom Limestone, were not so rich. The vein is said to have been somewhat irregular; it averaged about 6 ft. wide, carrying a mixture of fluor and galena.

The mine was shut down in 1910, the production being insufficient in view of the pumping required : the ' make ' of water was not heavy, being about 80 gallons per minute, but it all had to be raised to the surface, for the mine mouth is practically at stream level.

Grove Rake Vein, an E.–W. lode, crosses the Rookhope Burn 3 miles above Boltsburn village. It was wrought for galena, and traces of copper pyrites have also been found, though not in payable quantity. The mine was particularly active between 1880 and 1900, and all levels, even the high Slate Sills, were productive down to the Great Limestone, but trials below that horizon showed fluorspar only, and as the vein also turned poor at either end of the workings, the mine was abandoned in 1903, and is now regarded as a reserve for fluorspar alone.

Boltsburn Mine.

Owners.—The Weardale Lead Company, Ltd.

Site.—The main shaft is on the S. bank of Rookhope Burn, S.W. of Boltsburn village.

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* H. Louis, ' Lead Mines in Weardale,' *Mining Mag.*, vol. xvi, (Jan. 1917), p. 24.

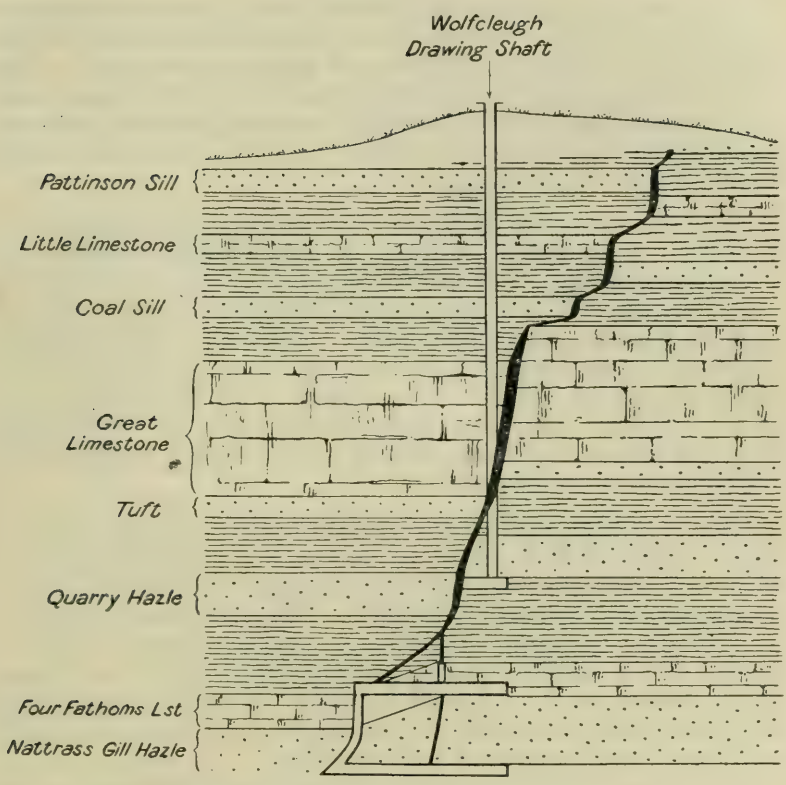

Fig. 1.—*Section of Wolfcleugh Mine.*
Scale: 100 ft. to 1 inch.

History.—This mine belonged to the Beaumont family until 1880: it has been in the hands of the Weardale Lead Company since 1883. In 1892 the famous Boltsburn 'flats' were struck, and since that date the mine has increased in importance, until it is now the largest producer of lead-ore in the United Kingdom.

Geology, &c.—The Boltsburn Vein runs along a small normal fault, trending about N.E., and usually with an upthrow S. of 2 ft., though sometimes this direction may be reversed. The vein has been proved for about 1 m. to the S.W. of Rookhope Burn, but for the last 30 years all the workings have lain N.E. of the stream, in which direction they now extend for nearly 2 miles.

The main drawing and pumping shaft, S.W. of Boltsburn village, is sunk on the vein to 30 fathoms, when it reaches the Four Fathom Limestone. The main haulage road, known as Watt's Level, runs from the shaft bottom along the vein to the N.E., through strata gently inclined in the same direction: after passing through the Great Limestone, it ends above the High Coal Sill, two miles from its starting point.

The vein may be 4 ft. wide, but is usually 2 ft. or less; there is commonly a 'liner' of iron carbonate,* the main body of the lode being composed of a mixture of galena and fluorspar. The vein is in itself hardly a payable subject, but after taking over the old workings, the Weardale Coy. extended Watt's Level and eventually met with the remarkable 'flats,' which are now such a leading feature in the mine.

The term 'flat' is in general use in most lead-mining fields to denote ore-bodies of a more or less horizontal character: the great majority of these are obviously mineral infillings of cavities previously leached out by water percolating along the bedding planes of Limestone strata: the 'flats,' 'caverns,' and 'pockets' of the Derbyshire and Flintshire mines are all of this character, as are many in the North of England fields also. The Boltsburn 'flats,' are altogether different: as will be seen from the description below, they are metasomatic replacements of limestone, on a large scale.

The 'flats' at Boltsburn Mine are found in the Great Limestone,† which is here 60 ft. thick, and are decidedly localised. They were not met with until the workings on the vein had been carried into the hillside for $1\frac{1}{2}$ miles, when they were discovered in following up some 'live' (*i.e.* galena-bearing) 'strings' leading off the vein into the surrounding limestone. The richness of the deposits may be gauged from the fact that although they have been steadily worked for nearly 30 years the total length of ground so far explored is only 520 yds.

The 'flats' lie at three main 'randoms' (horizons) in the limestone, termed the High, Middle and Low Flats respectively (*see* fig. 2); of these the High Flat random is the most productive,

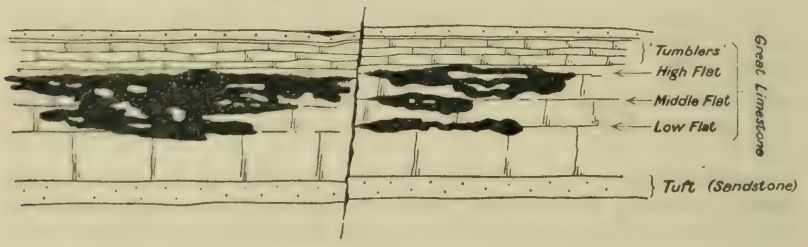

Fig. 2.—Section of 'Flats' in the Boltsburn Mine.
Scale: 80 ft. to 1 inch.

and is on occasion confluent with those below, when ore-bodies 25 ft. in height are got. The limestone on both sides of the vein may be affected, but actual contact between the vein and the

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* This mineral is more abundant S. of Rookhope Burn, where it was the chief product of the old workings, above adit level.

† One or two ore bodies have been got in the overlying sandstones, but these are ordinary infillings of cavities due to subsidence into the corroded upper surface of the Limestone: see Stephen Watson, *Trans. Weardale Nat. Field Club;* vol. i, (1904), part ii, pp. 148–149.

main mass of a flat is rare : there is commonly a belt of ' rider '* between, from two to six feet broad, through which tiny threads of galena sometimes extend. It is beyond this ridered zone that the flats are found, and they may continue for as much as 50 yds. away from the vein. A plan of the excavated area (fig. 3)

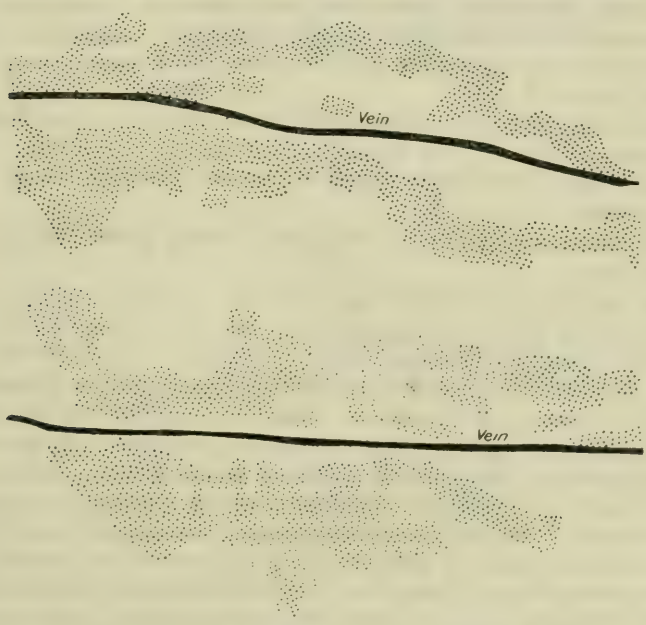

Fig. 3.—*Plan of ' Flats ' in the Boltsburn Mine.*
Scale : 150 ft. to 1 inch.

may give the impression that the flats have sharply defined boundaries, but as a matter of fact there is an insensible passage into unaltered limestone. The working faces show galena in irregular bunches and more or less horizontal lenticles, 2 or 3 inches thick and a foot or so long : these are scattered through dolomitised limestone, in which the bedding planes and fossils† can still be discerned, but which has a sugary, recrystallised appearance when compared with the unaltered rock. Small cavities, an inch or so across, and lined with fluorspar and dolomite crystals, are quite common, but ' chamber deposits ' on a large scale are extremely rare.

The ' flats ' have been followed towards the N.E. for 520 yds. : the workings are now under the head waters of Stanhope Burn. and show no signs of giving out.

Considered as a whole, the predominance of ore over the gangue minerals is remarkable : over 10 tons of galena per cubic

* The miner's name for a close-grained, ferruginous and dolomitic limestone, on the walls of a vein.

† Within the High Flat position there is a bed of ' cup corals ' (Clisiophyllids) in which the impartial replacement of matrix and skeleton by galena is very noticeable.

fathom is sometimes obtained, and there is an average of from 15 to 25 per cent. in the raw material, or 'work,' sent to the dressing mill.

The vein is generally poor in the vicinity of the flats, and is said to be ' robbed ' by them : it is better in the overlying Coal Sill and in the Little Limestone : the latter is succeeded by a sandstone (the Pattinson Sill) which was highly productive at one spot, known appropriately as ' Klondike,' but above that level nothing has been got.

Trial sinkings have been made down to the Four Fathom Limestone, but without result : no ' flats ' were found, and although the vein fissure persisted, it was mainly filled with gangue spars.

The water in the mine is not heavy, being about 150 gallons per minute.

Ore Dressing.—A full account of the working methods and dressing plant of the Boltsburn Mine has been given within the last few years by Professor Henry Louis in his paper on the Weardale field*, from which the following remarks are quoted :—

' The dressing mill is situated close to the side of the Boltsburn stream, about a quarter of a mile below the shaft. It is driven mainly by water power with auxiliary steam power. The crude ore, or ' work,' is brought from the mine in trains of mine-trams drawn by a locomotive, and is tipped into a hopper at the mill. Thence it runs over a grizzly which takes out the smalls, and passes over a short picking-belt on which lumps of clean galena, so-called ' potter ore,' of clean fluorspar, and of barren deads are picked off leaving the dressing ore or ' bouse ' on the belt. This passes to a 16 by 5 in. rock breaker, whence the broken bouse together with the undersize from the grizzly pass to the usual roughing and fine-crushing rolls, breaking everything to $\frac{3}{8}$ in. ; this passes through a sizing trommel, the over-size being returned to the rolls in the usual way. The crushed bouse is lifted by a bucket elevator to a set of trommels, making 5 sizes down to $\frac{1}{8}$ in., each size going to a set of 3-compartment jigs. jigging through the sieve on a bed of clean galena. The hutch-work is clean lead ore, ready for the smelt-mill, though the finer sizes are sometimes finished on a small flat buddle ; the middlings or ' chats ' are elevated to the chat-rolls for further crushing and the tailings or ' cuttings ' are lifted by an inclined overhead ropeway and deposited on the waste heap. Everything below $\frac{1}{8}$ in. goes to the slime-dressing plant. It is classified in spitz-kasten : the product from the first spigot is dressed on a Record table, the next on old-fashioned round buddles, and the finest on Brunton belts, which latter are here found to be very satis-factory. The heads from the round buddle are buddled again, and the heads from the Brunton belts are usually cleaned in hand dolly-tubs. All the fine tailings are settled in slime pits,

* Henry Louis, ' Lead Mines in Weardale, County Durham.' *Mining Magazine*, vol. xvi, (Jan. 1917), p. 15, &c.

whence they are dug out by hand and dressed, for the most part on Brunton belts. The ore is extremely easy to dress, and in spite of the somewhat crude type of plant, the results are satisfactory.' The dressed ore contains about 78 per cent. of lead; it was taken by a narrow-gauge railway to the smelt-mill,* situated about one mile up stream from the mines, until a year ago; the works, which were the last of their kind, once so common in the northern dales, were then closed, a modern plant on the sea-coast being utilised instead.

Stanhopeburn and Stotsfieldburn Mines.

Owners.—The Weardale Lead Company, Ltd.

Sites.—Stanhopeburn workings are on the N. side of Reahope Burn, above Stanhope: the Stotsfieldburn mine lies ½ m. S.E. of Boltsburn village.

These two mines may conveniently be taken together, since they both work the Red Vein and its associated lodes, east of the Rookhope valley.

History.—The Stanhopeburn Mine was wrought by the London Lead Company so long ago as 1801: their workings stopped along the W. side of Park Plantation. Stotsfieldburn Mine, nearly 2 miles further west, belonged 50 years ago to the Northern Lead Company, who advanced less than ½ m. east of Rookhope Burn. The tract intervening between the two mines (nearly 1½ m. long) was left untouched owing to difficulties with the landlords, but the whole property being now leased by the Weardale Lead Co., development is in active progress once more.

Geology, &c.—Both mines are on the Red Vein, trending W. 30° N., and with a downthrow N. of about 15. ft: on the Stanhope side the lode averages 12 ft. in width, increasing westwards to 26 ft. in places. The galena content is somewhat low, fluorspar being the chief mineral. Referring to Stanhopeburn Mine, Professor Louis remarks that it 'is opened up by an adit of about two miles long running westwards from the right bank of the burn. The face of the adit is in the Quarry Hazle, where the vein shows a little ore, though not payable. About 6½ fathoms above the adit or Horse level, another level has been driven in the Great Limestone. The vein here is also comparatively narrow and poor in lead. This pair of drifts is being carried forward in the Red vein, less with the hope of getting good lead ore in this vein than with the expectation of a rich strike where it is intersected by some of the S.E.–N.W. veins, which are known to cross it farther to the westward. Farther back the

* Professor Louis gives an account of this mill in his paper quoted above; since that was written, work has been stopped, so that a detailed description of the plant is unnecessary here.

Red vein is wide, up to 26 ft. in places, and carries a fine body of clean fluorspar, which is being got by magazine mining. There are two S.E.–N.W. veins at present being worked off the Horse level, namely, Reahope vein and Swan's vein. The former shows a promising vein in the Great Limestone. The latter has given satisfactory returns above the Horse level, and has recently been proved below it by means of a staple 16 fm. deep, equipped with hoisting engine and pumps driven by compressed air; at 9 fm. down, a cross-cut driven from this staple has cut Swan's vein, which carries well both as regards lead and fluorspar.'*

Both at Stotsfieldburn and east of Stanhope Burn the superficial parts of the vein carry much chalybite, and have in fact been worked for ironstone in past times. The strip of virgin ground now in course of development 'takes on' the Grindstone Sill at the hill-top: in the shafts which are being driven up to the surface the Firestone has been found to carry good ore-bodies.

No 'flats' of any kind have as yet been noticed in these mines.

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* H. Louis, *loc. cit.* p. 24.

CHAPTER II

DETAILED DESCRIPTIONS OF THE MINES (*continued*).

TEESDALE.

General Account.

Teesdale, in common with other valley systems in the north-eastern Pennines, is occupied in the main by sediments of Yoredale age, inclined very gently towards the east: the overlying Millstone Grit covers the hills towards the mouth of the dale. The Yoredale rocks show the usual alternation of limestone, sandstone and shale, the Great and the Melmerby Scar Limestones being the leading horizons: the latter, however, only outcrops towards the S.W. side, around Cronkley Fell.

The Whin Sill runs for many miles along the south side of the dale: this great dolerite sheet is intruded into the lower part of the Yoredale sequence, gently transgressing from the Melmerby Scar up to the Tynebottom Limestone.

The mineral veins are particularly abundant on the N. side of the main valley, where they are frequently arranged in clusters (Coldberry, Pike Law, &c.): the commonest directions are E.–W., or S.W., the cross veins, at right angles to these, being of less importance. The ore is generally galena, with minute amounts of blende: very rarely this condition may be reversed, as at Willyhole and Dirt Pit Mines. The gangue spars are mostly quartz, calcite, fluor (not in commercial quantity) and barytes: the latter is particularly common in the upper part of the dale, where several veins are now being wrought for this mineral.

From 1828 to 1908 the richest mines were in the hands of the London Lead Company and since their long tenancy ended little has been done: the small quantity of ore now raised is merely the by-product from the barytes workings.

Although the strata in Teesdale are practically identical with those near by in Weardale, there are notable differences in the character of the mineral veins traversing the two valleys. Not only is the prevalent fluorspar gangue of the Weardale veins replaced in Teesdale by other spars, but most of the ore came, not from the Great Limestone and underlying beds, but from the 'upper sills': further there is nothing at all comparable with the great metasomatic 'flats' of Weardale and Alston Moor.

The Whin Sill, as elsewhere, often contains thin 'strings' of galena, but nothing of commercial value: the one notable exception to this rule was at the Greenearth Mine, where the Sill proved remarkably productive.

A rapid impoverishment in depth is the general rule in Teesdale. There are some impressive instances of this in the upper reaches of Hudeshope Beck, where certain veins have given rise to extensive workings high up the valley sides, but on the lower slopes proved practically barren. The London Lead Company, with their prolonged experience of local conditions, refused to sink any deep shafts, and practically all their work was done from cross-cuts and adit levels driven in from the hillsides. The working plans of this Company are particularly instructive, as the sections had a colour scheme to denote the quality of the ore-bodies—yellow for 'poor ground,' red for moderately rich, and blue for 'very rich ore.' An inspection of these sections inclines one to believe that most of the workings are exhausted, but occasionally there is reason to think that good ore-bodies are still intact in the bottom levels : attention has been drawn to such cases in the following account of the mines.

Detailed Descriptions.

The *Sharnberry Vein* runs S.W. from the high ground near Pawlaw Pike : crossing the headwaters of Sharnberry Gill at Flake Bridge it divides, the northern branch (known as the Flake Bridge Vein) going W. by S. to join the Manor Gill Vein, the southern branch persisting S.W. across Eggleshope Beck, being there known as the East Rake Vein. At their outcrop all these veins traverse Millstone Grit as far as the Eggleshope valley, floored by the Firestone and the Grindstone Sills, below the Felltop Limestone.

The old Sharnberry Mine was in Sharnberry Gill, 1 m. S. by E. from the summit of Pawlaw Pike, levels being driven N. from the stream to cut the vein : these levels, and their air-shafts, would be in Millstone Grit strata, but in an old section of the workings, dated 1840, the highest bed cut is the Firestone, so that the section probably refers to one of the shafts alongside Eggleshope Beck, in the East Rake branch of the main lode. The section (*see* fig. 4) shows the vein inclined steeply to the S., passing without change through alternations of hard and soft strata, and especially productive where the 'plate,' or shale under the Grindstone Sill is faulted down against the Upper Slate Sill.

Apart from this section we have little information about the mine. There is an important note on an old plan, however, that the Sharnberry North and South Veins showed belts of very rich ore in the top levels, but that on sinking to a depth of 50 fathoms below surface, both veins split up and became useless.

The East Rake level was driven N. for 400 yds. to cut the lode, the workings being stopped in 1885 when they had reached the watershed S. of White Hill.

The *Flake Bridge Vein* crosses the beck 1 m. above Great Eggleshope Bridge, turning due W. to join the Manor Gill North

Vein. It was wrought on the E. bank of Eggleshope Beck from the Dusty Gill Level, and on the W. bank from Manorgill Low Level, opening straight on to the vein near the base of the Firestone Sill: ore was reported to have been very good here in the upper sills, dying out in depth.

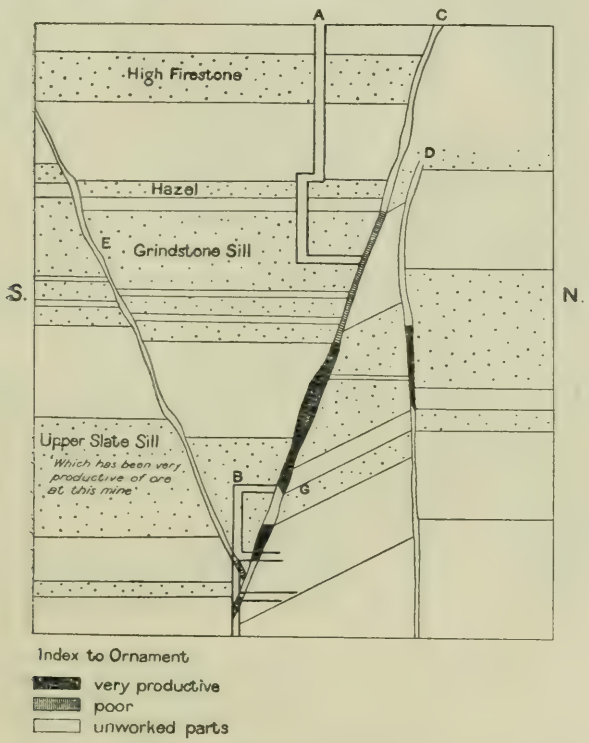


Fig. 4—Section at Sharnberry Mine, taken in 1848.
Scale: 44 fms. to 1 inch.

A.—Shaft sunk in 1832.
B.—Sharnberry Engine Sump.
C.—Sharnberry Vein.
D.—Part of vein split off.
E.—A branch vein (barren).
G.—Horizon of Sharnberry Level.

The *Old Wiregill Vein*, trending S.W., was wrought over a length of 600 yds. between Great Eggleshope Beck and Wire Gill, east of which little seems to have been done. Crosscuts were driven N. to intersect the *New Wiregill Vein*, a valuable lode which has been followed for 2½ miles, from the vicinity of Pawlaw Pike, W. and W. by S. past Round Hill to Great Eggleshope Beck, beyond which it seems to die out. The vein runs along a comparatively large fault, down 16 fathoms S., and the workings were in Millstone Grit, together with the high 'sills' near the Felltop Limestone: impoverishment in depth set in rapidly, the vein being of little value even in such a generally productive stratum as the Great Limestone. Above adit level

the lode is reported to have been 15 to 20 ft. wide, filled with an intermixture of galena and 'country rock.' The main level started in the High Coal Sill at Great Eggleshope Beck, and ran E. by N. along the vein for nearly 2 miles : from it a shaft was sunk 20 fathoms, on the N. side of Round Hill, and from the bottom of this shaft another level was driven E., a pumping sump being established near California Shop, at the head of Little Eggleshope Beck. At this point the main mine buildings were situated, access to the lode being got from a short cross-cut, passing through *Pott's Vein*, a parallel string which gave a fair yield of ore, but died out entirely below adit level.

The plans of the London Lead Company show that the Wire Gill Vein was highly productive in and above the main or Great Eggleshope Beck Level, but became poor in the lowest, or pumping level N. of California Shop : along certain stretches (*e.g.*, between the head of Wire Gill and the branch stream N.W. of California Shop) the vein was poor throughout.

On the N. side of Pound Hill the plans indicate that there was still 'very rich ore' for some 200 yds. along the floor of the bottom level when the workings were abandoned, but apart from this case the vein seems to have been exhausted : it is said locally that it became both poor and narrow when followed downwards into the Great Limestone.

Exploratory headings were drawn N. and E. for several hundred yards at either end of the Wire Gill workings, but without result. West of Great Eggleshope Beck the lode apparently dies out altogether.

The three veins known as Manor Gill North, Lodge Sike, and Lodge Sike Sun, all meet on the S.E. side of Manor Gill, where access was obtained to them from the Middle Level.

Lodge Sike Vein is much the strongest, and has been followed W. and S., for at least 3 miles, along a fault down S. 20 to 30 fathoms : near Manor Gill it was wrought not only from the Middle Level, but also from the Low Level, which started near the base of the Firestone Sill and was driven on the lode for 1 mile. The old plans of the London Lead Company show that the vein was very rich around the head-waters of Manor Gill, but only in the upper 'sills,' of which the Firestone was the chief producer. This condition apparently held further west, since on the left bank of Hudeshope Beck there are extensive waste heaps high up the valley side, at the mouth of Lodge Sike Level (driven under the Firestone Sill), but few signs of working along the course of the vein down towards the stream. The poverty of the lower strata is surprising, since these include the Great Limestone : nevertheless it is a fact, as was proved in the abortive trials from Marlbeck Low Level, which started under the Great Limestone on the E. bank of Hudeshope Beck, and was driven N.N.E. for $\frac{1}{2}$ m. to intersect the vein : when this was reached, a shaft with trial galleries was cut upwards through the Great Limestone into the floor of Manor Gill Low Level.

Pikestone Brow Mine.—The main cross-cut started at the E. side of the Hudeshope valley, and was driven N. for 650 yds. to intersect an E.–W. lode which is probably a continuation of Manor Gill North Vein. A subsidiary level, in strata below the Great Limestone, began in the valley bottom at Hudeshope Head Shop, and both were carried on northwards beyond the lode for 200 or 300 yds., but with little result. The vein proved disappointing in depth, and practically died out in the Great Limestone, being only just recognisable in the outcrop of that bed along the W. bank of Hudeshope Beck.

Further up the valley there have been several trials in the gully known as 'Parkin's Hush.' In 1898 the London Lead Company drove a level along a small vein seen here in the Great Limestone, and got a fair yield of ore from the overlying 'sills.' Since 1913 more work has been carried on by Mr. Raine, who started a cross-cut in the lower part of the limestone, which, after passing through the vein, turns S., keeping in limestone all the way, in hope of finding a 'flat.' Up to the present time this courageous venture has not been successful, and unfortunately the prospects are not bright, for in this neighbourhood the Great Limestone is, as we have seen, curiously unproductive.

At the head of Hudeshope Beck a group of small veins in the high 'sills' under the Millstone Grit has been wrought to some extent. The last workings were in 1888, when a cross-cut, known as the New Level, was driven N. from the stream for 700 yds.: no information could be obtained regarding this working.

Coldberry Mine.—This mine lay on the W. side of the Hudeshope valley, and wrought the Lodge Sike Vein and several parallel lodes lying to the S., known as Robinson's, Horne's, Richardson's, and the Sun or Lowe's Vein. In addition to these, the workings also touched the N. end of the important lode known as Hunt's Coldberry Vein (see the description, later on, of the Skears Mine) and further west, the two S.W. veins under Hardberry Hill, known as the North or Beadle's Vein, and Hardberry Hill Vein.

Apart from Lodge Sike Vein (here 27 fathoms down S.) and Hunt's Vein (5 fathoms down N.W.) all these lodes were associated with faults of but a few feet throw. They were wrought from four main levels: the highest of these was the Slate Sill Level, below this came Richardson's, and then the North or Hog Level, and Hunt's, both driven in the floor of the Firestone Sill. All the veins were highly productive in and above the Firestone Sill, but of little value in lower strata. Before the mine was closed, a trial cross-cut, called Bottom Level, was driven in the Great Limestone through the Lodge Sike Vein and then S. to Hunt's Vein under the opening of Hunt's Level. As the Limestone had proved useless, a rise was made, when under the mouth of Hunt's Level, into higher strata, and further explorations made along Richardson's South Vein towards

Hardberry Hill. This work was left unfinished when the lease expired, but it is doubtful whether a resumption would be worth while : the plans of the London Lead Company show that there was a considerable body of ' very rich ore ' left in the sole of North Level in both Hardberry and Hunt's Veins, but the results of the Bottom Level trial along the Great Limestone through Lodge Sike and other veins do not encourage one to believe that these ore-bodies continue in depth.

The Lodge Sike Vein terminates westwards in a series of sub-parallel lodes in shattered country-rock, well seen in the Red Groove open-cast. These lodes apparently died out below the Great Limestone and trial headings driven both N. and S. for nearly ½ mile found nothing of value.

Skears Mine lay south of Coldberry, and covered fully half a square mile. The main lodes ran in a general S.W. direction, and were known as Hunt's Coldberry Vein, Raine's Vein and seven others lettered B. to H. ; there were also a few cross strings running S.E., but these were of no great account. Access was obtained through two cross-cuts, (1) the Firestone Level, starting on the E. side of the Coldberry–Middleton road, and driven over ½ m. N.W., and (2) Skears Low Level, opened on the right bank of Hudeshope Beck opposite Low Skears, and nearly 1 m. long.

In the N. and N.W. parts of the mine, most of the ore came from the Upper Sills, and Skears Low Level (started in 1821 by the London Lead Company) proved disappointing. The termination of Low Level in Hunt's Vein is only 33 ft. above the mouth, and lies just above the Three-Yard Limestone : the mouth is cut in the Great Limestone, so that there is a rise in the strata of some 26 fathoms along this cross-cut.

Vein C, 12 ft. down S., was poor and little wrought : the cross vein at the W. end was excellent in the Great Limestone, but poor at other horizons.

Vein E, 20 ft. down N.W., carried a pocket of ' very rich ore ' where cut by the Firestone Level, but elsewhere was poorer, and in the Low Level useless : this vein passes southwards into Vein D_2, which was highly productive in the Coal Sill and held one good ' pocket ' in the Great Limestone, but nothing below.

Hunt's Coldberry Vein, 30 ft. down N.W., was about 10 ft. broad in the Firestone Level, diminishing to 2 ft. in the Low Level beneath, where good ore is believed to be still intact : the whole lode thinned out towards the south, in the direction of Ravelin Vein.

Taking the mine as a whole, no indication of ' flats ' ever seems to have been got in the Great Limestone, and there is no doubt that the workings must be considered as exhausted.

Marlbeck Mine.—Little seems to be known about the character of the veins in this long-abandoned mine. The lodes are reported to have been very good (one of them was 5 or 6 ft. wide) in the Great Limestone, but below that horizon they ' pinched '

out rapidly. An inspection of the original Geological Survey 6-inch map, made about 1870, when good plans were still available, gives the impression that the ground has been thoroughly explored in a series of long levels and cross-cuts, and is probably exhausted. The same remarks apply to the workings further south, at High Skears, in Graham's, Walton's and Skears Old Veins.

Flushiemere Mine worked three lodes on the E. bank of Flushiemere Beck: they were (1) the Low Vein, running N.W., (2) the Black Vein, parallel to Low Vein, and on a fault 32 yds. down E., (3) Vein C., an E.–W. lode north of the others. The main cross-cut started by the streamside at Flushiemere Shop: it was driven N.E., and after cutting Low and Black Veins, turned N.N.W., and so continued for $\frac{3}{4}$ m. before being abandoned. Five or six small strings were cut in this trial, but Vein C. (wrought 1827–30) was the only one of value: when in the Great Limestone, the workings on this vein broke into a natural cavern 500 yds. long, which was explored, but only one or two strings of galena could be found. So far as galena is concerned, this mine is probably no longer of much account, but the old workings are noteworthy in that they contain witherite in commercial quantity, while they also gave 'flats' of ore in the Great Limestone and in that respect are almost unique in Teesdale.

Pike Law Mine.—There is a remarkable complex of veins here, over 30 having been proved within less than a square mile. Judging by the extent of the surface workings, much ore has been got, but nothing ever seems to have been done below adit level. Quite possibly a few of the lodes may yet carry workable ore in depth: the workings are so ancient that no sound information can now be obtained regarding them, though the direction and nomenclature of the different veins were carefully noted on the Geological Survey map (six-inch scale) made about 1870.

The Great Limestone and higher sills outcrop over the whole area, and it is reported that 'flats' were got in the Limestone, and that some are still intact at 'Leonard's Hush,' on the W. bank of Flushiemere Beck.

Dirt Pit Mine.—Near the foot of Ettersgill Beck, on the left bank of the stream immediately above Dirt Pit steading, a zinc-blende and pyrites ore-body was opened up in 1906. A cross-cut was driven through smashed 'country-rock,' (iron-stained shale and sandstone) and within a few yards intersected an E.–W. vein carrying blende and iron pyrites in a matrix of ferruginous sandstone fragments, cemented by calcite. Twenty tons or so of ore were taken out, and are still lying at the level mouth: the work was not proceeded with, as it was not possible to effect a satisfactory separation of the minerals. The lode was never fully proved, but is probably only a pocket, since the veins seen in the streams immediately E. and W. carry oxide of iron only.

Langdon Beck.—Two small mineral fields were wrought up this valley. The first is about a mile N. of the Alston–Middleton main road, and held fourteen E.–W., and S.W. lodes lying on either side of the West Beck. The main cross-cut, known as Langdon Low Level, started below the Four Fathom Limestone and was driven N.N.E. for 600 yds., cutting 4 veins through which access was got to others. Most of the workings, marked by an abundance of old shafts, were in the Great Limestone and higher strata, but nothing is known as to their nature; nor could anything be ascertained about the other field at the head of the Langdon valley, save the lie of the veins and sites of the old shafts and levels.

Highfield Mines.—North of the Alston road and Grasshill House, three S.W. lodes were wrought, known as Grasshill North, Middle Streak, and Black Lead Veins, along with the Low and High Cross Veins, trending S.E. Most of the ore seems to have come from the Great Limestone and higher beds, but the lowest adit, known as the Baking Level, was driven under the Four Fathom Limestone, on the Black Lead Vein; judging from the small size of the waste heaps at the mouth of this level, the lodes ' pinched out ' below the Great Limestone : there is a good deal of barytes around the old shafts at Highfield Hushes.

South of the main road are other veins in much lower strata. Grasshill Shaft, 300 yds. N.E. of Mount Pleasant, was sunk 34 fathoms, to the base of the Tynebottom Limestone : this bed, along with its adjacent strata, seems to have been highly productive on the vein complex around Rough Rigg, but we have no information as to the thickness and character of the lodes.

Ashgill and *Langty Mines*.—The chief lode, known as the North Langty Head or Ashgill Head Vein, can be traced in a general E.–W. direction for about $2\frac{1}{2}$ m. along the Teesdale–Weardale watershed, and is associated with a fault down S. 18 ft. There is a line of old shafts sunk directly on the vein, and in addition there were two cross-cuts : one of these, in the Great Limestone, starts in the gully N. of Manor Gill House. The second, and much lower one, begins in the Three-Yard Limestone at the bend of the Alston main road at Ashgill Head Low Shop : it was known as the Ashgill Head Level, and was driven northwards for nearly $\frac{3}{4}$ m. before cutting the main lode : thence it ran westwards to Ashgill Head High Shop, where it entered the North Vein, and subsequently continued as a cross-cut on the Four Fathom Limestone to join the Scraithhead (Weardale) workings.

The North Vein carried blende and galena, while the Langty Veins seem to have yielded galena only, in a matrix of quartz, fluorspar and aragonite. Since adit drainage could not be carried out below the Three-Yard Limestone, it is possible that

there may still be good ore-bodies in lower strata, about the Tynebottom position, as at Rough Rigg, Ladyrake, &c. : this is purely conjectural, however, for we have no knowledge as to the state of the bottom workings when the mine was abandoned.

Ladyrake Mine.—The vein worked here, by Harwood Beck, runs S.W., and is a direct continuation of the Black Lead lode of Grasshill, having a downthrow N.W. of 20 to 40 ft. A drift, known as Wigram's Level, was first opened on the vein off Harwood Beck and carried for 530 yds., being abandoned in 1889. Alongside the level mouth, a shaft (Jansen's) was sunk 17 fathoms, to the base of the Jew Limestone, and from the bottom a level was driven N.E. for 90 yds. and thence S.E. for 140 yds., when a cross-vein was reached, the intersection of the two lodes yielding ' very rich ore.' A dolerite dyke is reported to have been cut just before the cross-vein was reached : beyond the latter, according to a plan in the Raby Estate office at Middleton, the Jew Limestone, hitherto flat, suddenly rose up southwards at 32°.

On the waste heaps galena and a little blende can be seen, along with quartz, discoloured barytes and iron-stained ' country rock.'

The mine was very wet, and at the present time water overflows from the shaft at 40 or 50 gallons per minute. All workings were stopped in 1891. According to reliable reports the vein was 4 or 5 ft. wide in the bottom levels, and the best ' pockets ' had been exhausted.

Cadger Well.—In the upper reaches of Harwood Beck, 400 yds. E. by S. from the junction of the old and new Alston roads, trial cross-cuts were driven in 1890–91, towards the N.W., in search of the South Langty Vein : several small strings were cut in line with that lode, but nothing of value got. The work was resumed in 1900, and a branch cross-cut driven to the S., through clay, rubble, and ' solid whinstone,' but was abandoned 60 yds. S. of the stream. The venture seems to have been initiated by the discovery of a quantity of loose galena, highly argentiferous (80 ozs. of silver per ton) along the stream banks, but as this was in the loose surface gravel and drift, it may have travelled a long way from the parent lode. Other abortive trials in this neighbourhood were made 700 yds. N. of the main Alston road (the Redgleam trial) and again S. of Crookburn Bridge, immediately over the county boundary into Westmorland.

Greenearth (or Greenhurth) Mine.—This mine is remotely situated on the northern slopes of the upper Tees valley, $1\frac{3}{4}$ m. S. of the county boundary on the Middleton-Alston main road. The original workings seem to have been on three E.–W. veins, reached by a level cross-cut driven N. for $\frac{3}{4}$ m. from the old hill track on the south side of Viewing Hill. Subsequently another vein-group, lying further west, was wrought (Annie's, South

Cross and South End Veins). These lodes all trended S.S.E.; they were worked alongside the old road from a shaft 75 fm. deep, which started in the Tynebottom Limestone and ended just below the Whin Sill. The mine yielded galena and a certain amount of zinc blende : it was highly productive, both in the ' Whin Sill ' and in the overlying strata. The ore-bodies were said to be 4 or 5 ft. wide even in the bottom levels, with no sign of improvement in depth. The workings were eventually flooded out, in 1902, but the water overtook the old-fashioned pumps quite slowly, and is reported to have been not more than 80 gallons per minute.

On the waste heaps are fragments of galena and blende, along with much quartz vein-stuff and dolomite, some barytes and calcite : there is a quantity of dolomite, many blocks showing veinlets of galena and quartz.

Greenearth is one of the very few mines in the North of England which have carried good ore-bodies in the Whin Sill, and, for Teesdale, is remarkable for its richness even in the lowest levels, 75 fathoms below surface : were it not for the long distance (12 miles) by road to the nearest rail-head at Middleton, the re-opening of the mine with modern pumps might be well worth consideration.

Dubbysike Mine, nearly 1 m. E. by S. from Greenearth shaft, is an old working on a galena-barytes vein, running W. 25° S. Within the last few years it has been reopened by the Hedworth Barium Coy., to recover barytes left by the ' old men ' ; this spar yields a fair quantity of galena, but as a by-product only. This also applies to the numerous barytes lodes of the *Cowgreen Mines*, where the galena, scattered irregularly through the spar, amounts to 1 or 2 per cent. of the whole ' bouse ' (raw material) and is separated by hand picking.

Isabella Mine, N. of Cowgreen, was a small opening on a S.W. vein averaging 4 ft. wide, with a few small pockets of galena in the vein-stuff; the Teesdale Cross Vein, 8 to 13 ft. wide, and running S.S.E., was tried here from a cross-cut, but contained little galena, though barytes was plentiful. The small trials further north, known as Jane Ann and Martha mines, proved useless.

Willyhole Mines.—These lie on the south side of the Harwood valley, and were opened on some small lodes running W. by S. up Willyhole Sike, carrying galena, blende and barytes. The work, started by the Teesdale Lead and Zinc Mines, Ltd., soon came to an end, and a recent exploration of the old shafts and levels proved disappointing. About $\frac{1}{4}$ m. further north, on the right bank of Reddycomb Sike, there is another old working along an E.–W. vein, the ore being chiefly blende, with galena in subordinate quantity. A few years ago the Hedworth Barium Co. put down a trial shaft and reopened the bottom level, when the vein was found from 2 to 3 ft. wide, occasionally increasing to

10 ft.; one mass of blende was got which was 2 ft. across. The ore-body was not considered large enough to warrant the establishment of an efficient dressing plant, and the work was stopped. On the waste heaps there is much blende, often in blocks 4 inches across, besides a certain amount of barytes. The Willyhole and Reddycomb mines, and the opening at Dirtpit, were the only producers of zinc blende in Teesdale in anything like commercial quantity.

Maizebeck Mines.—There is no reason to think that any of the small galena workings up the Maizebeck valley (Birkdale Hush, Maizebeck Shop, &c.) would now be worth reopening, and little information about them could be obtained. In the offices of the Vieille Montagne Co. at Nenthead (Alston) there is a plan and section, made by T. Sopwith in 1828, of the *Silverband Mines*, which lay 1½ m. S.E. from the foot of the Maize Beck: this shows a shallow trough of 'hazle' (sandstone) with limestone bands above and below, the latter (termed the Whin Top Limestone) resting on the Whin Sill. A main or 'horse' level was driven along the hazle, and from it shafts were sunk down to the Whin Top Limestone, where ore was got: the shafts were continued a few yards further down, into the dolerite, but apparently without result. A rise from the horse level up into the higher post of limestone gave good results, most of the ore being got, apparently, from this part of the mine.

CHAPTER III.

DETAILED DESCRIPTIONS OF THE MINES (*continued*).

SWALEDALE.

General Account.

Galena-bearing veins abound on the hillsides on either side of Upper Swaledale, but they are particularly numerous on the northern slopes, between Keld and Marske. The direction of these lodes is predominantly E.–W. or S.E., and they traverse horizontal or very gently inclined Yoredale strata, capped by Millstone Grit on the highest ground. The gangue spars call for no special remark : they are calcite, quartz, and barytes, with some fluorspar. In the last days of the Old Gang Mines, barytes was turned out in some quantity, but it was generally discoloured and of inferior grade.

The dale was at one time a very active mining centre, but after the workings had been carried down some distance, impoverishment of the ore-bodies set in rapidly, and all work practically ceased many years ago. On every hand, repeated with monotonous insistence, one notices lodes which, though very rich on high ground, proved worthless when followed towards the lower slopes of valleys : in other words, the local drainage system has cut right through the mineralised zone.

The number of veins which have been wrought at one time or another in Swaledale must total several hundred, so that it is only natural to expect that small amounts of galena have occasionally been overlooked, and are still intact. Such ore-bodies can only be expected in the form of new veins or strings concealed under drift, or perhaps as lateral extensions of known lodes. In so far as the old workings are concerned there is little or no inducement for their resuscitation : the evidence for their deterioration in depth is altogether too impressive.

As the mines are considered to be exhausted, no effort seems to have been made to keep the working plans. The course of the known lodes, with the position of the chief levels, were delineated with great care on the original Geological Survey six-inch field maps, made about 1880, when active work was still in progress. This information, supplemented by a brief visit to the ground, and by notes supplied by Mr. Edward Cherry, agent to Sir Francis Denis, is the basis of the following brief account of the district.

Detailed Descriptions.

East of the village of Keld the Stony Hill and Swinnergill Mines wrought the *Cockrake* and other veins, these being associated with faults traversing the Ten-Fathom Grit and Great Limestone

in a general E.–W. direction. The Swinnergill mines lie at the head of a steep valley, 300 ft. above the river: they could be readily drained by adits driven from the river side, but as no such attempt seems to have been made, one may infer that the lodes died out in depth, below the Great Limestone. The south-easterly veins of Arn Gill and West Arn Gill, S. of the foregoing, also seem to have soon given out in depth: the workings can be traced down the hillside to the Undersett or Four-Fathom Limestone, but fail beneath that level. An attempt to reopen Arn Gill Mine was in progress during 1919: the old workings are said to have found pockets and 'flats' of ore in the Four-Fathom Limestone, some of them 3 or 4 yards long, but none in the Great Limestone, though the vein itself was good at that horizon.

Gunnerside Beck, which flows southwards to join the Swale at Gunnerside village, crosses several valuable lodes. The headwaters run slightly S. of E. alongside the *Blackethwaite Vein*, which lies along a fault bringing down Millstone Grit to the north, and was wrought from four cross-cuts. The lowest, and main, level entered the hillside by the stream below Eweleap Scar, in the floor of the Great Limestone; it was driven N. for nearly 700 yds. to cut the lode: galena was obtained, with calcite, barytes and fluorspar in the gangue. The Blackethwaite Vein was wrought eastwards for $2\frac{1}{2}$ m., while 3 m. to the west it was proved from Stonesdale Moor Engine Shaft, sunk 49 fathoms 5 ft., to the Undersett Chert. At Stonesdale, most of the ore came from a subsidiary vein, and the Blackethwaite lode itself proved barren, although it was driven on for 200 or 300 yds. to the east. The eastern reaches of the lode were wrought from Punchard Level, in the Great Limestone at Little Punchard Gill: this cross-cut, driven southwards, cut first the Cocker Vein, from which it was carried forward to the Blackethwaite lode.

The *Blind Gill Vein*, S.W. of Blackethwaite Mines, has an unusual direction, trending slightly W. of N. The outcrop traversed the Ten-Fathom Grit, and the lode was wrought chiefly from Blind Gill Level, just below the Great Limestone. When tried off Priscilla Level, in strata 22 fathoms lower, it proved of little account, most of the ore giving out below the Four-Fathom or Undersett Limestone.

About 2 m. above Gunnerside village the beck crosses a complex network of E.–W. lodes at Lownathwaite Mines, these continuing eastwards to join the *Old Gang* group. The earlier workings were by opencast (North Hush on the right bank, Gorton, Friarfold and Bunton Hushes on the left) and levels (Priscilla, Prosper and Bunton Levels) and by this means ore was got out to a depth of some fathoms below the Undersett Lime. Subsequently an extensive cross-cut, known as Sir Francis' Level, was started lower down the valley, in strata below the Five-Yard Limestone. Sir Francis' Level ran northwards for over $\frac{3}{4}$ m., and on striking the *Old Rake* turned E. along that lode

for a further ¾ m. : near the intersection of vein and cross-cut an ' engine sump ' shaft was sunk 40 fathoms below the floor of the level. The lower reaches of the lodes, as tapped from this level and in the ' engine sump,' proved on the whole to be disappointing : in accordance with the general rule, the ore-bodies, although rich in such high lying beds as the Ten-Fathom Grit and Great Limestone, gave out rapidly below the Four-Fathom or Undersett Lime. This also holds good further down the beck, where the *Barbara* and *Silver Hill* lodes carried much ore on either side of the valley down to the Undersett, but below that level were useless. In face of these facts there is no reason to doubt the correctness of the local opinion that the various mines up Gunnerside Beck are practically exhausted.

The vein complex of the Lownathwaite Mines spreads out beyond the stream, the great lode known as *Friarfold Rake* turning N.E. across the head-waters of Hard Level Gill and on to Surrender Mine, 2½ m. from Gunnerside Beck : diverging from it, the *Old Rake* runs E. across Hard Level Gill, and at its termination ¾ m. further on was known as Reformer's Vein. Both of these ' master veins ' are accompanied by subsidiary and more or less parallel lodes (Brandy Bottle, North Rake, Alderson's, Moorhouse, Freeman's and others), the whole forming the Old Gang mines, wrought from adits and cross-cuts : in all of them the ore-bodies dwindled below the Great Limestone. So far as known, no ore reserve of any consequence remains in the old workings, though there are probably considerable quantities of pink barytes of inferior quality. One of the many instances of rapid impoverishment hereabouts is provided by *Cherry's Vein*, a branch of the Friarfold Rake : when proved N.N.W. of Bell's Shaft, at the head of Hard Level Gill, this lode gave much galena in the Great Limestone and its overlying chert, part being in the form of ' chamber deposits ' : below the limestone the ore disappeared.

The Old Gang Mines had an extensive dressing and smelting plant alongside Hard Level Gill, 4¼ m. W. of Reeth village. Further supplies for these mills were also got in three parallel N.W. lodes, wrought near by from Hard Level. Ore was also dealt with from Victoria Level, ½ m. W. of the mills : this was a cross-cut driven in strata close under the Great Limestone, and ran for nearly ¾ m. to the S.W., cutting the two S.E. lodes, known as the Watersikes and Watersikes Sun.

The *Watersikes Vein* is wrought out so far as the Victoria Level workings are concerned, but little is known about the S.E. extension of the lode across Brownsey summit, and it is possible that untouched ore may still exist in that direction : a trial cross-cut has been made west of the summit cairn, but without result, and it is held that the true course of the vein lies further west. The Victoria Level workings ended westwards at ' Jock's Cross-cut,' driven S. from the extension of Sir Francis' Level along the Old Rake. There is thought to be a strip of

virgin ground worth exploration, between the cross-cut and an old trial level immediately S. of the small reservoir E. of Gunnerside Beck.

The lodes marking the eastern continuation of the Surrender and Blackethwaite groups meet at Dam Rigg Mine, on the hillside above Arkengarthdale, 1 m. S. of Whaw. From a purely structural point of view, the most noteworthy lode here is that connected with the Sun or South Mid Vein of Surrender, for at Dam Rigg this is associated with a 60-fathom fault, down S, by which the base of the Millstone Grit is brought almost opposite to the Great Limestone. One of the chief openings hereabouts was the Danby Level, driven S. for fully $\frac{1}{2}$ m. on the Undersett Lime: another cross-cut, driven in strata 25 fathoms lower down, started at the foot of Dam Rigg Cross Hush $\frac{3}{4}$ m. S. of Whaw: this ran S.W. for about $\frac{3}{4}$ m., but, judging from the small amount of debris at its mouth, seems to have been relatively unproductive.

On the south side of the 50-fathom fault, various branch lodes proceed E. by S., and were extensively wrought in the vicinity of Tottergill and Moulds Bottom. All these mines, in common with those at Dam Rigg and further west, seem to have been very rich in their upper levels. In depth they must have deteriorated rapidly, for their lowest workings hardly ever get below the Undersett Lime. It should be remarked that the mines are at a high elevation, with ample facilities for adit drainage at much lower horizons than were ever wrought: the absence of any attempt to tap these lower beds tells its own tale. Exactly the same phenomena recur on the other side of Arkengarthdale on the hillsides E. of Eskeleth: here the *Windegg* and *Freeman's Veins*, crossing the ridge in the Ten-Fathom Grit and Great Limestone, were wrought on a large scale both in opencast and from adit levels: all workings cease below the Undersett Lime, though this is 500 ft. above the valley bottom at Eskeleth Bridge. Further south, similar results attended the working of the Cocker Rake, Black Vein, North Rake and Tanner Rake, north of the hamlet of Booze. *Tanner Rake* continues S.E. to Fell End Mine, where it splits up near the surface into innumerable strings. Some of the deeper horizons seem to have been tested here, for a cross-cut to the vein starts on the Three Yard Limestone, 250 ft. above the River Swale: apparently the attempt was unsuccessful, for the dump at the entrance to the level is quite small. The lodes rejoin eastwards to form the *Racca Vein*, reported to have carried much pink barytes, and which runs into an intricate meshwork of E. W. lodes on the high ground S.W. of Washfold village: most of the ore here seems to have come from the Great Limestone and overlying strata.

The Great Limestone again proved highly productive in the uplands N.E. of Reeth, where it was traversed by the *Copperthwaite* and *North Copperthwaite Veins*, running N. of E. The North Vein is on a downthrow N.W. of 15 ft. and does not seem to have been of much account, but the main Copperthwaite lode is

marked by a continuous string of old shafts and refuse heaps over a mile long. On the topmost slopes of the hillside opposite Reeth levels on this vein are found down as far as the Undersett Lime, while trials were made on the Three Yard Limestone below, but were obviously unproductive. At the N.E. termination of the lode nothing seems to have been done beyond the Stelling road, where the workings come to an end in the Great Limestone.

The veins on the south side of Swaledale are thin and widely scattered compared to those north of the river. The largest working was at Grinton How Mine, 2 m. S. of Reeth, where the main lode, *How Vein*, ran for a couple of miles in a W. by S. direction across Cogden Gill and over the summit of Greets Hill. The lowest working adit was Swinston Level, on the W. side of Cogden Gill, and it was driven below the Undersett Lime; How Level was further up the hill, in the Great Limestone, and still higher the lode was wrought opencast and from shallow shafts. How Level ran to the Low Greets Shaft, 400 yds. S.W. of the summit cairn, and is reported to have found ' lead in flots.' A cross-cut from this level went N. to intersect the North Vein, which branched off N.E. from the main lode, dying out within ½ m. Trials in both lodes below the Undersett Lime proved fruitless.

The Grovebeck Mine, further W., also wrought a vein trending W. by S., which gave ore in the Great Limestone and overlying strata.

To the S.W. of Gunnerside several thin strings trending S.E. were worked, those at the Spout Gill Mine being the most important : these strings were in themselves of no great account, but associated with them, in the Great Limestone, were many rich ' flats ' : it is not known whether these were replacement ore-bodies or chamber deposits, but the latter is the most probable. Flats were also got south of Thwaite, at the Providence Mine, on a string in the Great Limestone running slightly E. of S. : one of these, known as the ' Modesty Flat,' was working in 1882, but the venture soon came to an end, there being far too little ore to warrant an extensive development scheme. It may be noted that nothing in the least comparable to the great metasomatic or replacement flats of Weardale has ever been got in Swaledale, and there is no reason to believe that such ore-bodies will ever be found there.

PATELEY BRIDGE AREA.

In the northern part of this field the lodes traverse Millstone Grit strata, while to the south, around Greenhow, they lie in massive Carboniferous Limestone. In the northern area the *Lolly Mine* was in active operation from 1889 to 1910, working a N.E. vein on the right bank of the River Nidd, 1 m. above Ramsgill. The lode was 3 or 4 ft. wide, carrying galena in a matrix of barytes, and ran along a fault down S.W. The main adit was driven directly on the vein from the riverside at Lolly Scar, through

grits, showing rich ore-bodies: on extending the workings to the limestone the ore gave out, and the mine being wrought out, was abandoned. Four miles further south is the *Stony Grove Vein*, running E. by S. past Merryfield Hall and Ivin Waite towards Water Gate, a total distance of over 3½ m. The Merryfield Mines were wrought from adits and shafts sunk on the vein at Ashford Side Beck: east of the stream the lode divided, the southern branch being wrought from the Providence Mine, the northern from the Prosperous Mine: these workings were partly drained by Wonderful Level, a cross-cut starting on the right bank of the stream, opposite the foot of Ashfold Plantation, and driven W. by S. for ½ m. The Sun Side shaft, 420 yds. S.W. of Prosperous Mine, was unwatered by Wonderful Level to a depth of 96 yds., while Perseverance Level, opening on Brandstone Beck near Throstle Nest, drained the Ivin Waite workings to about the same depth. The S.E. range of the vein was reached from Eagle Level, cut from Brandstone Scar towards the S.W. for ½ m., but the vein was thinner here, and seems to have died out near Water Gate.

The output from the Stony Grove mines, obtained from Millstone Grit strata, kept two local smelt mills in work for many years, but no reliable information could be obtained as to the thickness, quality or condition of the lode in the bottom levels. It is, therefore, impossible to say whether there is any prospect of obtaining workable ore-bodies in the underlying Carboniferous Limestone: it is true that this rock has yielded much galena along its outcrop further south, at Greenhow, but it by no means follows that it would be equally productive in depth, under the Stony Grove workings.

Greenhow.—In the neighbourhood of Greenhow Hill, 3 m. W. of Pateley Bridge, the Carboniferous Limestone outcrops in a marked anticline, prolonged to the east in two inliers surrounded by Millstone Grit: it forms a massive bed supposed to be at least 1,000 ft. thick. Within the main mass galena mining has been resumed of late years, but nothing has been done in the two inliers for nearly 30 years. The information as to the inliers is only of a generalized nature: in the eastern one, several S.E. veins were wrought by the Moss Pits Mining Co., one of the shafts, 700 ft. N. by E. from High Fleak Gate, being 75 fathoms to the limestone: these workings were probably connected with the Perseverance Level in Broadstone Beck, as that is the only adit capable of draining to such a depth. In the western inlier, several S.E. lodes were also wrought, the *Carnet Vein* being taken out to a depth of 60 fathoms: these workings seem to have been drained by an extension of the Cock Hill and Gill Field Levels, which open on Brandstone Beck, ½ m. to the N.W. A cross-cut driven southwards from the Carnet Vein met with several other lodes (Folly, Hazle, Haiding, South and New South Veins) all of which were wrought under the Millstone Grit cover. The Cock Hill Level also drained a complete network of lodes, mostly

E.–W. and S.E., which traversed the nose of the main anticline of limestone around Greenhow Hill : by this means the ground was unwatered to a depth of 50 or 60 fathoms : as at the Carnet Mine, the veins were followed well under the Millstone Grit cover south of the limestone outcrop, but we have no reliable data as to their condition, although we know their direction and that of the leading cross-cuts. Our information is much more complete with regard to the Craven Cross field further west, for within the last few years many of the old workings there have been re-opened : they are now known as the Greenhow Mines, though they are fully a mile west of Greenhow Hill itself.

The Greenhow Mines.

Owners.—The Greenhaugh Mining Company, Ltd.

Site.—On Craven Moor, S. of the Grassington–Pateley Bridge road, and about 1 m. W. by S. from Greenhow Hill.

History.—Lead-ore has been raised here possibly from Roman times onwards, the most active period being 1800–1890 : all work then ceased, but in 1916 the Greenhaugh Mining Company re-opened some of the old mines, and are now producing galena, fluorspar and barytes : the Company's mine manager, Mr. Varvill, has published a full account of these operations,* which has been of very material assistance in compiling the following descriptions.

Geology, &c.—The lead-ore deposits are in massive limestone, lying in normal fissure veins, in 'flatting beds' and in vertical pipes. The galena is associated with calcite, fluorspar and barytes, and usually occurs in solid ribs on one or other of the vein walls, or forming a core in vertical pipes.

Veins.—The productive veins are closely set and trend in a general E.–W. direction : they are occasionally crossed by others bearing N.–S., or N.W., these being generally barren save at points of intersection. The N.–S. veins are supposed to throw, and therefore to be later than the E.–W. group : Mr. Varvill has pointed out,† however, that while a cross-vein may appear to shift the outcrop of a E.–W. lode 40 or 50 ft. laterally, yet a parallel vein a few yards away may either not be affected at all or may even be 'thrown' in a contrary direction : this being so, there can be little doubt that mineralisation was later than all the fissuring, and of the fissures themselves, the N.–S. set are probably the earliest : as Mr. Varvill suggests, the N.–S. fissures have merely served to direct the course of the mineral bearing solutions : otherwise any apparent movement would have been repeated in the parallel veins. This point is referred to at some length as it is of vital importance in searching for a lode which has been suddenly 'lost' in meeting a cross-vein.

* W. Varvill. 'Greenhow Lead Mines.' *Mining Magazine*, vol. xxii, No. 5 (May, 1920), pp. 275–282.

† *Loc. cit.*, p. 277.

The chief lodes are the North Rake and the Craven Vein north of the high road, while south of these are Fielding, Waters and Jamie Veins; beyond these are the Blackhill, Foxholes, Harker, and Harding Veins. The lodes south of the high road are partly drained by the Blackhill Level, which opens on the hillside S. of Dry Gill steading: it is driven along the Black Hill Vein, with connections to Gill and Foxholes Shafts, unwatering the ground to a depth of 35 fathoms: the two shafts have been re-opened and development work is now being done from them.* The Jamie Shaft showed good ore underfoot in the Jamie and Lonsdale Veins, which is to be drained by an extension of the Blackhill Level.

The Greenhow mining field is notably fortunate in one respect: information as to the behaviour of the ore-bodies in depth is provided by the Bradford Corporation Aqueduct Tunnel, constructed about 1909 to link up the Nidderdale Reservoirs with Wharfedale. This tunnel is driven in a S.W. direction, passing under the high road at Keld Houses and thence across the Greenhow field at between 4 and 500 feet below the ground. Mr. Varvill notes (*loc. cit.*, p. 279) that 'while passing through the limestone it cuts in 3,500 ft. no less than 14 veins with an east-west strike. Of these 6 were bearing payable lead-ore where the tunnel cut them and the remainder were not, though they were of a 'kindly bearing' nature, which might easily bear on encountering a cross-vein or branch-vein. One of the veins cut, the Craven Cross Vein, contained a rib of solid galena at least 1 ft. thick, and yielded 11 tons of clean galena in lumps, by simply driving the 7 ft. by 8 ft. tunnel heading through it, the smalls being allowed to go to waste. Two other veins, the Blackhill and Harker, which the present company is now working, were also very rich where the tunnel intersected them.' As most of the old workings did not get below the 35 fathoms limit of the Blackhill Level, there is every prospect that large quantities of virgin ore still remain in depth.

The '*Flatting Beds*.'—There are three well-marked horizons, known as the Top, Middle and Bottom Flats, where ore-bodies lie between the bedding planes of the limestone. They have been wrought from the outcrop at Nursery Knott, N. of the high road opposite Dry Gill steading: four shafts were sunk here, and the 'flats' were particularly rich where cut by veins. Further east, an old working in one of these 'flats' was discovered when Gill Shaft was re-opened: this shaft was sunk on a vertical 'pipe,' apparently due to the intersection of a couple of veins, and the 'flat' opened off the shaft about 15 fathoms down. The heading dipped N.E. at 15° (1 in 4) and an inspection of the walls of both pipe and flat showed that they were not metasomatic replacements, but were 'chamber-deposits' due to the infilling

* Varvill, *loc. cit.*, p. 281.

of water-formed cavities. White barytes and fluorspar, with particles of galena, were noticed, and there was a fine red clay also. In his diagrams of a typical Greenhow ' pipe ' Mr. Varvill (*loc. cit.*, fig. 7, p. 279) shows that the red clay generally occurs as an inner core, surrounded by galena, with the gangue spars filling the main body of the cavity. Similar clays are commonly found covering the ore bodies in the great chamber-deposits of the Derbyshire mines.

The Gill Shaft flat has a maximum thickness of 3 ft., but rapidly dies out to a mere trace on either side of the heading : since the original cavity is due to irregular solution of the limestone along a bedding plane, sudden ' pinches ' and swellings are to be expected.

Regarding the flatting beds at Nursery Knott, Mr. Varvill states (*loc cit.*, p. 281) that one of the old mines ' has been reopened, and an old incline drift down the bed is being cleared. It is proposed to work the barytes here which is very abundant, much of it being in the form of " deads " or old stope-fillings. This bed, which has been worked along its outcrop for about 300 yards by the old lead miners, consists of solid barytes with clay on top. The old miners only worked the lead ore where it occurred in patches, leaving the greater part of the bed intact in pillars. Some of these are 5 ft. high and of solid barytes. The bed dips at about 15° to the horizontal, and is free from water. Access has been made to a point about 200 ft. below the outcrop, but the old workings continue deeper than this.'

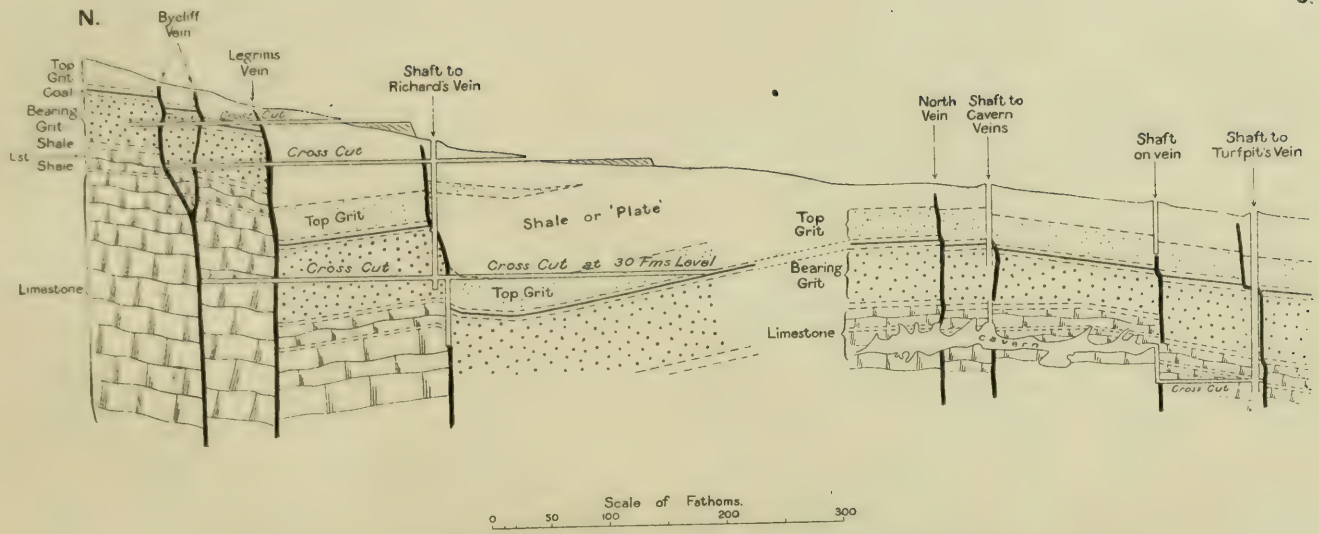
GRASSINGTON.

General Account.

The leading mines in the Grassington district lay on the high ground N.E. of the village : they were abandoned 40 years ago or more, though the waste heaps continue to be turned over at times for fluorspar.

The local geological structure is simple : on the hilltops east of the River Wharfe, there is a capping of Millstone Grit on massive Carboniferous Limestone with occasional shale partings, the whole series inclining gently towards the east. This arrangement is complicated by numerous faults trending E. by S., accompanied by minor flexures. Galena veins are associated with most of these faults : their productivity, though high in the Millstone Grit measures, fell rapidly when they were followed down into the underlying Limestone.

The veins may be arranged in two main groups, (1) round Yarnbury, 1¼ m., N.N.E. of Grassington, and (2) the Bycliffe group, from 1 to 1½ m. further north. The general sequence of strata in the old mines is as follows :—



SECTION AT THE BYCLIFFE MINE. GRASSINGTON.

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The 'Lead Measures' on Grassington and Hebden Moors.

	Fms.	Ft.	Ins.
Red Scar Grit	20+	—	—
Shale and girdle beds	35	—	—
Top Grit	8 to 9	—	—
Shale	3 to 5		
Coal	—	—	2 to 20
Bearing Grit	12	—	—
Shale	5	—	—
Grit	4	—	—
Shale	5	—	—
Limestone			

The chief horizon for lead-ore in the foregoing sequence is, as its name implies, the 'Bearing Grit,' which outcrops all over the main field. The Red Scar Grit 'takes on' to the dip, on either side of the Gate Up Gill valley, but few of the veins extend so far east.

Detailed Descriptions.

The Bycliffe Vein, the master lode of the district, lies on the northern fringe of the field: trending E. by S., it can be followed for fully 8 m. right across to Nidderdale. On Grassington Moor it was wrought for many shallow shafts and levels (Groove Gill, Peru, Bycliffe, How Gill and Green Bycliffe Mines) but when followed over the edge of the Millstone Grit escarpment it soon dies out in the Limestone below. The lode is lost immediately beyond Green Bycliffe Mine, situated about 100 ft. below the base of the Grit: a similar result seems to have attended a trial in depth at the Bycliffe Mine, where a cross-cut from the 30-fathom level in Richard's Vein cut the Bycliffe lode about 130 ft. down in the Limestone (see Plate I). On the eastern side of the field the vein was reached by a cross-cut known as Speculation Level, in Trunla Gill, which was driven northwards in the Red Scar Grit for nearly $\frac{3}{4}$ m.: judging from the small size of the waste heaps, this venture was unsuccessful. In Gate Up Gill a branch lode, the *Trow Scar Vein*, was tried at the foot of Red Scar from an adit level, supplemented by a shaft 35 fathoms deep, from which a cross-cut to the vein was made. Near the foot of the shaft the Top Grit was struck, but lay too deep for the workings, which were soon abandoned.

Close to the Bycliffe Mine an important lode known as *Legran's* or *Legrim's Vein* (sometimes also as the Palfrey Vein) led away westwards from the S. side of the Bycliffe Vein, being associated with a fault down S. nearly 30 fathoms (see Plate I) on the surface, this lode can be traced for about 150 ft. down into the Limestone, but ends at the Porphyry Shaft, S.E. of Gill House. To the south, a network of lodes (Slanter, Ringleton's, Burnt Ling, Middle Vein, &c.), all on small faults down S., were productive in the Bearing Grit, but their outcrops cannot be traced lower than 150, or at the most 200 ft. below the top of the Limestone measures.

The veins at the Yarnbury Mines are closely set, there being 7 or 8 within a belt less than 400 yds. wide. The most northerly lode, *Grey Vein*, has been followed, including its branches, for nearly 2 m. : it runs along a large fault, down S. 30 fathoms. A similar displacement accompanies Cockburn's Vein, which branches off the main lode at Hebden Beck, and E. of Bolton Gill leads into the Star Vein, down S. 16 ft. The rest of the Yarnbury lodes (Beever, Devonshire, Simpson's, Cross-cut Vein, &c.) run along smaller faults, all down S. except the New Rake, which throws 3 to 5 fathoms in the contrary direction. A large part, if not all, of the workings were drained by the Duke's Level, opening on the W. bank of Hebden Beck, ½ m. above Hole Bottom steading, at an altitude of 850 ft. This level, driven about 100 ft. below the top of the Limestone, would unwater the Yarnbury mines to a maximum depth of 50 fathoms. A further 100 ft. could easily have been drained by an adit downstream, at Hole Bottom, but as no such work was attempted one may infer that the veins were unprofitable below the horizon of Duke's Level. This conclusion is confirmed by an examination of the outcrops at the west end of the field, where all the veins die out 150 ft. below the top of the Limestone. Others are known to the west, from 1 to 200 ft. lower down the escarpment, but they seem to have no direct connection with the Yarnbury lodes, and to have been mere ' stringers ' of little value.

As regards the future possibilities of the Bycliffe and Yarnbury mines, it is true that though the workings were but shallow the lodes were both numerous and rich, especially in the Millstone Grit. A reopening of the mines and their extension in depth, well into the Carboniferous Limestone, may therefore seem feasible, for this rock is generally a most productive source of lead-ore elsewhere. Such a project is nevertheless to be discouraged : it is abundantly clear that on the western side of the field, at any rate, the veins extend no further than 200 ft. down into the Limestone, most of them considerably less than this. Farther east, the section across the Bycliffe field (Plate I) shows that the Limestone measures were tried there, as they were also in the Yarnbury group, from the Duke's Level : had the ore-bodies persisted in depth, these workings could have been readily extended and drained by adits driven as cross-cuts from Hebden Gill or directly on the veins from the lower slopes of the limestone escarpment facing the River Wharfe : that no such ventures were undertaken surely indicates that impoverishment in depth had already set in throughout the existing workings.

South of Grassington the massive ' knoll ' limestones of Elbolton and Kcal Hill are traversed by many thin galena lodes, trending slightly S. of E. Fourteen have been mapped on Elbolton alone, the leading ones being known as *Smith's*, *Cobbler's*, and *Middle Veins* : a disused level is still visible on the west side of this hill, but nothing could be ascertained regarding the thickness or quality of the lodes. The workings, which were

abandoned in 1908, seem to have been shallow and are probably exhausted.

Other veins, also trending E. by S., have been worked in limestone at Appletreewick Pastures, 4 m. E. by S. from Grassington. The direction and nomenclature of these veins were indicated on the Geological Survey 6-in. field map, made about 1870, but no other information has been obtained : no great amount of ore seems to have been raised. In addition, several lodes were also wrought on a small scale north of Appletreewick village : they were known as *Summer's*, *Napoleon*, *Derby*, *North* and *Stony Nook Veins*. Access was obtained by a cross-cut level driven from the dry valley above the village, the most considerable working, nearly 400 yds. long, being on the Derby Vein : an extension of the cross-cut northwards ended in the Stony Nook Vein, which was cut 200 ft. below surface. Apart from the workings on Derby Vein the mine—abandoned about 1883—hardly seems to have got beyond the development stage, and must have proved very disappointing.

Mines near Kettlewell.—In the upper part of the limestone massif, east of the River Wharfe, and about 5 m. N. of Grassington, there are old workings on E.–W. lodes, the most important being the Old Providence and the Hooksbank Veins. The *Old Providence Vein* lies S. of Dowber Gill and has been wrought for nearly a mile. At the west end these workings were reached by a cross-cut, known as the Low Level, starting at the top of the steep bank 100 ft. above the stream, and driven southwards. The lode was cut within 350 yds., and the level continued for a further $\frac{1}{4}$ m. along a cross-vein : some E.–W. ' strings ' were met with, but none were of any value. The Middle Level lay nearly $\frac{1}{2}$ m. further east, and 125 ft. above Low Level : still further east the vein was worked in the Millstone Grit measures, being reached by a heading driven in a coal seam at the bottom of an old shaft, another cross-cut leading N. to Smith's Vein.

The *Hooksbank Vein*, trending N. of E., lay north of Dowber Gill, and was reached by a cross-cut opening 150 ft. above the stream. It is obvious that much lower reaches of both the Old Providence and the Hooksbank Veins could have been tapped by levels driven from the water's edge, instead of so high up the bank : the absence of any such attempt clearly shows that the ore-bodies gave out in depth, and as a matter of fact neither lode can be traced downhill beyond the 1,200 ft. contour line : the lowest workings lay about 350 ft. below the top of the Limestone.

The E.–W. lodes known as the *North*, the *Silver Rake* and *Twenty Meres Veins*, 4 m. N.E. of Grassington, run along a series of step faults, with a downthrow S. of 3 to 12 yards. They carried good ore in the Bearing Grit, and were tried in the Limestone beneath : the Fearnought Shaft, sunk on the Silver Rake near Mossdale Beck, was 48 fathoms deep, the upper 25 fathoms in grit, the rest in limestone with shale partings. The Silver

Rake is known, in its western range, as the Moorhead Vein, and in common with the Twenty Meres lode, splits up into several minor strings which can be followed downhill to the lip of the escarpment, where they die out 350 ft. or less below the top of the Limestone measures.

AREA SOUTH OF CROSS FELL.

Silverband Mines.—The chief vein here is a barytes-galena lode : the outcrop starts in the Tynebottom Limestone above Middle Tongue Beck, and thence runs E. through the Whin Sill and higher beds up to the Great Limestone S.W. of the summit of Great Dun Fell. The lode is reported to have been 20 ft. wide, and was wrought by the London Lead Company, who obtained a high yield of galena from the Four-Fathom and Great Limestones. Lower strata were tried from the ' New Silverband Level,' west of the waterfall in Middle Tongue Beck, but proved useless for lead-ore, barytes and films of manganese oxide being the only minerals found : these features were repeated in Rupert's Vein, a subsidiary ' string ' north of, and parallel to, the main lode.

At Silverband Mines the main lode divides, two branches proceeding N.E. past the summit of Great Dun Fell, and a third due E., along Dunfell ' Hush ' : this latter branch was extensively wrought from a level at the E. end of the ' hush,' which ran along the Four-Fathom Limestone, below which no ore seems to have been got in any of the three veins. A cross-cut, nearly $\frac{1}{2}$ m. long, was driven from Silverband northwards to a small lode at the head of Middle Tongue Beck, but apparently met with little success.

In 1919, the old workings at Silverband were reopened for barytes, which forms the vein-stuff in all the lodes : it is held that the mines are exhausted so far as galena is concerned, and judging by the poverty of ore below the Four-Fathom Limestone, further explorations in depth do not seem advisable. In support of this view, it may be noted that the main Dunfell lode can be traced for nearly 2 miles E. of the old level mouth, through strata ranging down to the Scar Limestone, but although tried at several points, it was unproductive.

Dufton Fell Mines.—Around the head-waters of Great Rundale Beck the Melmerby Scar Limestone outcrops in a ring of precipitous cliffs, and in the steep slopes above them are thinner bands of limestone, &c., with the Whin Sill at the top covered by the Tynebottom Limestone : all these strata lie horizontally. Several veins, running slightly N. of E., cross the ravine : on the western slopes, on Threlkeld Side, there have been extensive galena workings, and it is said that most of the ore was got, not in the Melmerby Scar Limestone, but in the ' hazel,' or sandstone, above : the course of the old workings is now

entirely obscured by scree. On the E. side of the ravine, information of a more definite character can be obtained : four lodes, known as Barrow and New Veins, with Dobson and Sun Dobson to the N., can be easily traced. Access to them was obtained from a level cross-cut, starting at the extreme head of the valley, just above the Whin Sill, and thence driven S. across the lodes : in addition there were levels driven directly on the veins themselves. All these workings did well above the Whin Sill, in the Tynebottom and Jew Limestones, but trials below this horizon proved fruitless, even in the Melmerby Scar position.

In the summer of 1919, the Longfell Barytes Coy. reopened an old level on Barrow Vein, in search of barytes. On the north cheek of the lode, in the Tynebottom Limestone, large tabular crystals of barytes were found, and several good pockets of galena, the best yielding about 25 per cent. of ore. No doubt a fair amount of galena may yet be obtained in the walls of the old galleries, but there is no reason to expect any reserve in depth; the rapid impoverishment of the lodes below the Whin Sill is only too evident in the sections on either side of the neighbouring ravine.

Scordale (Hilton) Mines.—The Melmerby Scar Limestone, in its outcrop at the head of Hilton Beck, carried 'flats' rich in galena : these were completely exhausted by the London Lead Company over 30 years ago : the waste heaps show quartz, calcite, traces of malachite, and quantities of fine amber-yellow fluor.

On the hillside opposite these old mines, occasional lumps of galena are met with in the barytes workings; they are especially abundant in the limestone immediately under the Whin Sill, where they sometimes bulk more largely than the spar.

Reviewing the general distribution of the ore-bodies along the main Pennine escarpment facing Appleby, at Silverband, Dufton and Scordale, it will be seen that galena occurs at progressively lower horizons proceeding south. There is no single horizon common to all the mines : and all the workings become rapidly impoverished in depth, the productive zone being less than 300 ft. deep, even at the Silverband Mine.

Lunehead Mines.—These mines lie $4\frac{1}{2}$ m. N.E. of Brough-under-Stainmore : the London Lead Company wrought them extensively for galena, and after lying idle for many years, they were reopened by Mr. Reynoldson of Brough. The ore now got is but trifling in amount, the staple product being barytes.

There are ten veins, running in a general N.E. direction : all of them are associated with small faults (4 fathoms at most) down S., with the exception of Hunter's Hush Vein to the east, which has a downthrow N. of 5 fathoms. The main cross-cut level starts alongside Cleve Beck, N. of the Middleton-Brough road, in a strong shale or 'plate' above the Four-Fathom Limestone. It is driven S., in which direction higher strata are cut, until it ends in the Great Limestone, which is the chief ore

and spar producer for all the veins. The most remarkable feature in the mine is the extensive series of natural caverns in the Great Limestone. When these were first discovered, they were partially filled with a stiff red ' gutta-percha ' clay, from which a considerable quantity of galena dust was got ; in the walls lenses of barytes are common, some carrying a little ore, but the good ' pockets ' have all been worked out. There is no true lode in any of the caverns, but there is one in close proximity, known as the Cavern Vein : this is about 2 ft. broad, full of barytes, with galena-bearing portions on the ' cheeks,' not in the centre, of the vein. The ' Little White Vein,' E. of the main level, is marked on an old plan as ' worthy of trial (? for galena) while to the W., Vein I. is believed to have good prospects also : pending a rise in prices, these possible reserves remain intact, attention being devoted to barytes instead. The spar often carries minute specks of copper pyrites, partly converted to malachite.

The mine is fairly dry, the water generally amounting to about 10 gallons per minute.

In the barytes workings at Cabbish Mines, in the Brough district, galena is scattered through the spar, and figures as a by-product in the output, but the quantities are, and will probably remain, quite insignificant.

CHAPTER IV.

DETAILED DESCRIPTIONS OF THE MINES (*continued*).

DERBYSHIRE.

General Account.

History.—It is generally believed that the Derbyshire lead-ores were among the first to be worked in Britain. The nature of the country renders this highly probable, for the veins, running across hills which are bare of Glacial Drift, and in many cases even of soil, would be among the first to attract attention. There is good evidence of the existence of mining operations from Roman and Saxon times onwards,* and the fact that output still continues, after 1800 years, testifies to the richness of mineral wealth in this region. The need for safeguarding the rights of the mining community led to the early institution of special laws and privileges,† which, so far as the large area known as the 'King's Royalty' is concerned, are still observed to-day.

Up to about the middle of the seventeenth century 'firing' was the only method in use of getting the ore. The fire of wood or coal was built against the face of rock, and lighted in the evening, the law prohibiting the lighting of a fire before 4 o'clock. By the next morning the vein-stuff was found so far loosened as to be wedged or picked down. Many of the old hillocks contain great quantities of cinders and in several cases fires have been found in the old workings, which had never been lighted. In a vein 300 yards west of Over Wheal, near Sheldon, an unlighted fire was found by an old miner; about a peck of coal was laid against the face of rock and supported below on two irons, placed about a foot from the sole of the level. The irons had rusted into an almost shapeless mass, and the coal had all 'run together' with rust.

But in the seventeenth century we hear of the introduction of blasting by German miners, sent for by Prince Rupert (probably between the years 1636 and 1645) to work the copper mines at Ecton.‡ Dr. Plot, writing in 1686,§ reports the mine abandoned,

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* See The Geology of . . . . . North Derbyshire. *Mem. Geol. Survey*, 2nd edn. 1887, p. 118, also 'Lead and Lead-Mining in Derbyshire,' by A. H. Stokes.

† Manlove, E.—The Liberties and Customs of the Lead Mines within the Wapentake of Wirksworth, composed in Meeter. 1653. (Reprinted 1851 and 1880). *London.*

Houghton, T.—*Rara Avis in Terris :* or the Compleat Miner . . . . The Liberties, Laws, and Customs of the Lead-mines, within the Wapentake of Wirksworth, in Derbyshire . . . With an Explanation of the Miners Terms of Art used in this Book. 12mo. *London.* 1681. 2 Ed. 1729.

‡ Chemical Essays by Bishop Watson. *Cambridge*, 1781.

§ The Natural History of Staffordshire, fol., *Oxford*, 1686, p. 165.

but it was resuscitated some twenty years later, and when the water had been got out, ' it was admired by all Miners that saw it, what Blast Holes had been bored, most a Yard or four Foot long, and two Inches or more Diameter, so that in those Days they used not such small Holes as we do in these.'*

Towards the latter part of the eighteenth century the shallower parts of the veins had been nearly exhausted. The annual produce of Derbyshire was estimated at 5,000 or 6,000 tons by Pilkington in 1789. This was not so large as twenty years previously. ' Hillocking,' that is, turning over the old mine-hillocks in search of ore, was introduced about 1720 by Welsh and Cornish miners, and now followed with more than usual assiduity, while several great soughs (water-levels) were being driven to relieve the mines at Wirksworth, Youlgreave, and Castleton (*op. cit.*, p. 127). The completion of the soughs set free the more heavily watered parts, but Farey writes in 1811, ' It may be right however here to mention, that most of these Soughs have proved unprofitable speculations, owing to the tedious time they were in driving, the Miners in the meantime continuing their exertions by pumping and short Soughs, much of the Ore was got before the great Soughs began to act, but more owing to the Mines, particularly in the lower lime Rocks, growing poorer as they descended, and ceasing entirely to carry Ore in many situations, where the highest expectations were entertained by the Miners and Soughers.'†

After the work had been carried down to the level of the great Soughs little was done. Mine after mine was abandoned, often owing to the impossibility of coping with the large feeders of water,‡ and for forty years or more the only large scale working has been at the Millclose Mine, near Matlock. Large quantities of fluorspar and barytes have been raised, and even more got by ' hillocking,' but, apart from Millclose, the production of lead ore has been small.§

Geology.—The limestone massif of Derbyshire is arranged in a great anticline, elongated from north to south. On the east two small inliers are also known, at Crich and Ashover. In all, some 1,500 ft. of limestone are involved, along with contemporaneous volcanic rocks, and their base is not seen : the fossils show that even this great thickness of strata represents only the uppermost division of the Carboniferous Limestone sequence.

Innumerable mineral lodes traverse the main dome. They are also found in the two inliers and practically all of them carry

* The Miner's Dictionary, &c., by William Hooson, 8vo., *Wrexham* 1747 (*s.* Boring). The level driven by the German Miners is now pointed out as the ' Dutchman's Adit,' and the drill-holes are still distinguishable.

† Agriculture and Minerals of Derbyshire, vol. i, p. 332.

‡ The flow from the Hillcar Sough alone has been estimated at 15,000 gallons per minute.

§ At the time of writing (November 1919) five mines were producing lead-ore, but of these Millclose and Ashover are the only ones of importance.

galena or its derivatives to some degree, in a variable matrix of calcite, barytes or fluorspar. These lodes are of diverse types, all more or less related to ordinary veins, and the great majority run within 45° of a general east and west direction. Except at Millclose the few that have a more northerly trend are of no great importance.

The mineral deposits are particularly rich and numerous at the northern and eastern flanks of the massif, where in several cases they have been followed miles beneath the overlying grits and shales ; to the south and west they are few and far between. The central areas, apart from the notable ' Hubberdale Pipe,' near Taddington, are poorly mineralised.

Some of the larger veins, or ' Rakes,' can be traced into the heart of the dome but in that direction diminish in value. Long Rake, near Youlgreave, for instance, runs for at least seven miles, and the Tideslow-Great Hucklow Rake almost as far.

The Ores.

Lead and Silver.—The commonest ore of lead is galena (sulphide of lead).

The proportion of silver ranges from 2 to 4 oz. per ton, and is therefore too small for profitable extraction, except in the manufacture of white lead, to the colour of which its presence would be detrimental. The greatest yield of silver in one year (since the commencement of the publication of the Annual Mineral Statistics) occurred in 1859, and amounted to 3,000 ozs., the yield of lead-ore in that year being 10,929 tons ; but of late years no return of silver has been made. A remarkable exception occurred in the case of the Balls-eye Mine, near Bonsal, thus described by Short: —' The richest part whereof yet discovered was *Balls-eye*, which was a natural Grotto formerly filled with Ore, even so high, that above Bonsal Brook it reached within a Yard of the Day. This Ore, tho' none of the beautifullest (being of a blackish dusky colour) yet was the richest in the Neighbourhood, for each Fudder of it on refining afforded about twenty Ounces of good Silver [a fudder of lead is 22½ cwt.] . . . . This Ore was so full of Sulphur, that in Smelting, a blue Flame of a Hand breadth thick stood over it . . . . The more Silver is in the Ore, the more Sulphur it contains.' Farey (*op. cit.*, vol. 1, p. 407) alludes to the yield of silver by this mine. This, however, was an exceptional case, and the staple produce of the Derbyshire mines was galena. Many of the deposits proved to be extraordinarily rich, though in most cases there is little but tradition as to the amount actually raised. Such information as has been obtained will be given in the description of the mines.

The next most abundant ore of lead is the ' White Ore,' ' Wheatstone,' cerussite, or carbonate of lead.* This ore appears

* *See* the North Derbyshire Memoir, 2nd edit., 1887, p. 126, &c.

in most cases to have resulted from the decomposition of a vein of galena. The White Ore in the mine near Newhaven (p. 47) occurred in a pocket in the limestone, filled with white and purple clay and sand, in a situation therefore in which it must have been fully exposed to the action of percolating water for a long period, certainly from pre-glacial times. Brown lead-ore or 'linnets' (mimetite, arseniophosphate of lead), green lead-ore (pyromorphite), and yellow lead-ore (phosgenite) are also found, but the last two merely as cabinet specimens. A muriate of lead also is described by Klaproth (Phil. Mag., vol. xvii, p. 86, 1803) and matlockite, or oxychloride of lead from the Level Mine, Cromford, by Greg (Phil. Mag., Ser. 4, vol. ii, p. 120).

An antimoniated ore of lead is said to have occurred at Eyam and Ashover. Pilkington writes, 'a large mass of lead ore partly solid, and partly antimoniated, with several veins of petroleum running thro' it was found in the Gregory Mine, Ashover.'

Zinc-ores.—Blende, calamine and small amounts of silicate of zinc occur along with lead ores in some of the veins, but the distribution of these minerals is sporadic and irregular, and they are always in subordinate quantity. The only blende deposits of any note at the present time are at Millclose Mine. Much calamine was got in the past, but as in Derbyshire this is an alteration product developed near the outcrop of blende-producing veins, the deposits were easily worked, and it is improbable that any further supplies can now be got on a commercial scale.

The Ore-bodies.—The ore occurs in Rakes or Rake-veins, Pipes, Pockets, Caverns, and Flats. The Rake is usually a nearly vertical fissure, resulting apparently from the widening of a joint in the limestone by the solvent action of water. The walls, however, not infrequently show slickensides, running horizontally or vertically or at any intermediate angle, while the strata are found to have suffered displacement, and the rake cannot then be distinguished from an ordinary fault, except in the commercial value of its contents. The greater number of the Derbyshire rakes, however, are merely vertical cracks, running for a limited distance either across country or downwards. A small rake is known as a scrin.

The ore in a rake usually occurs in ribs, separating layers of calc-spar, barytes, or fluorspar, and more or less parallel to the walls of the vein, the 'growth' of the mineral deposit appearing to have commenced on the walls of the vein and extended inwards till the vein was filled. Frequently, however, the galena is found in isolated crystals, scattered through a mass of spar, or in thin concentrically arranged layers, alternating with barytes, in the spherical masses often formed by this mineral. In some districts the galena has been found to occur, with little or no spar, in a network of scrins traversing a mass of limestone.

The Pipe or Pipe-vein has yielded a large part of the Derbyshire ore. It is formed by the widening out of a rake or scrin in one or more beds of limestone, sometimes owing to their greater solubility, at others owing to their resting upon an impermeable rock. The cavity thus formed takes the shape of a pipe, inclined as the beds are inclined, and enclosed on all sides by solid limestone, except where the rock is cut through by the rake or narrow scrin. The crack so caused is known as a 'leader,' and is followed by the miner in search of another pipe. The thinnest leader of spar or clay, or a slight oozing of water, has frequently proved a true guide from one pipe to another. The ore in the pipes is frequently found in lumps, lying in a confused mass of calc-spar, barytes, limestone blocks, and clay, as though the mineral had been broken up, after its original deposition. In some cases, however, the galena occurs as a fairly regular bed, following the inclination of the pipe, and enclosed in calc-spar that has been crystallised out in concentric layers upon the walls, floor, and roof of the pipe. It may be supposed that the pipe was originally formed by the action of water following a joint; that, the volume of the water having found another course, the pipe became filled, or partly filled, with 'mineral;' but that in many cases, owing to the water running again along the old channel, the mineral contents of the pipe were undermined, and allowed to fall into a confused mass.

The Flat, or Flat-vein, is of less common occurrence. It appears to differ from the pipe in being of indefinite width, though like the pipe it is bounded above and below by limestone. Flat-veins have been usually formed along the junction of two beds and may be compared to the lines of hollows which may be seen to follow such junctions in the faces of cliffs.

Pockets are deposits in chambers on the side of a rake.

The Caverns are of highly irregular shape, and are generally only lined, or partially filled, with ore and 'spar,' often covered with a dark red clay. The last-formed minerals have therefore grown in comparative freedom, the giant 'dog-tooth' calcite being especially noteworthy.

From what has been said above, it will be seen that almost every variety of hollow in the limestone, whether joint, fault, or old water-channel, has been found to contain ore under suitable circumstances. The nature of the contents of such hollows depends partly upon the rock in which they occur, and partly on the locality. It has been found by long experience that, though lead-ore occurs in all the beds of the Derbyshire Carboniferous Limestone, yet the bulk has been obtained from the top of this formation (the 1st Lime of Farey).* The lodes are not

* It occurs also in the Yoredale Shale, and more rarely in the Kinder Scout Grit (Alport Heights, near Wirksworth) and even in the Coal-Measures (Memoir on the Geology of the Yorkshire Coal Field, 1878, p. 44.) but in such small quantities as not to affect the truth of the above generalisation. See also Binney, *Mem. Lit. and Phil. Soc., Manchester*, Ser. 2, vol. ix, p. 125).

only more numerous in the upper than in the lower beds of the limestone, but they have proved far richer. In the case of the rake-veins particularly, most of the rich deposits of ore have been found immediately beneath the Yoredale Shale. Farey remarks on the comparative poverty of the mines in the lower limestones in the work already quoted. The late Mr. Wass in a letter, dated March 23rd, 1868, wrote : 'My own experience certainly confirms what has been frequently advanced, namely, that *as a rule* our veins are stronger and more productive in the upper than in the lower parts of the limestone.'

The toadstones,* or contemporaneous volcanic rocks, which occur at three or more horizons in the limestone over a portion of the area, are mostly unproductive, and are said to 'cut off the ore' (*i.e.*, ore is rarely found beneath them). As a generalisation this is fairly correct, but exceptions are known. It is true that the joints which have passed under the name of rakes in Derbyshire in consequence of their richness in ore, as well as the scrins, are frequently lost to sight altogether on sinking into the toadstone, though a similar joint may be found in the same, or nearly the same, line beneath it.† But that the stronger veins, especially those forming lines of fault, are continued through the toadstone has been repeatedly proved.

It is, however, a well-known fact that the vein is changed in character, and almost always for the worse, on entering the toadstone. It is frequently broken up into a number of irregular strings of spar, or pinched into a thin leader as at Millclose Mine. The toadstone, from its tougher character, seems rather to have crushed than to have broken clean along the line of displacement, and any hollow that might exist would be more probably filled with the copious residue left by decomposing toadstone, than by a mineral deposit. In several cases, notwithstanding, considerable quantities of ore have been raised from the toadstone.

The history of the Seven Rakes Mine, near Matlock, is instructive; the vein was worked first in the top limestone, and some years afterwards in the second limestone, the intervening toadstone being left untouched by both companies. Subsequently

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* The name is probably a corruption of *todtstein* (*lit.* dead-stone), as suggested by Prof. John Phillips (De la Beche *Geol. Observer*, 2nd edit. p. 559, footnote). It should be noticed that the rock is usually termed 'channel' by the miners. It was formerly called also 'blackstone.'

† Messrs. B. de Villiers, Dufrénoy, and E. de Beaumont state that out of 180 veins observed, 161 disappeared in the toadstone, while 19 passed through it (*Ann. des Mines*, t. xii, p. 339). Cotta remarks that a vein, becoming unproductive in the toadstone, would be said by the miner to be cut off by it (Ore Deposits, 8vo., *New York*, 1870). Farey (*op. cit.*, p. 249) writes, 'The Vein underneath a Toadstone Bed is seldom nearly of the same width, or of the same nature exactly, as that above it, nor are they exactly under each other, although generally they follow about the same range. Veins with such deviations are said to be *squinted*, or leapt aside . . . ., which is in some cases so considerable that Law suits have arisen, to determine whether they are the same Vein or not.'

five working men took a set of the ground in order to work the vein in the toadstone, and the undertaking proved profitable.*

One of the most important properties of a sheet of toadstone is its impermeability to water. The rock itself is less liable to fissures than the limestone, and its upper surface has usually decomposed for a depth of several feet into a clay of sufficient tenacity to hold up water. The outcrop of a toadstone is usually marked by springs and ponds (a noticeable feature in a limestone country), and in many instances veins, which were heavily watered above a toadstone, have been worked with little inconvenience in the limestone below it. This influence on the underground circulation of water may explain the rule that limestones above a toadstone generally produce most ore : in such beds the enlargement of joints and fissures by water action would be common, and free spaces for ore depositions in quantity would thereby be provided.

The most productive zones, however, are not equally rich in all localities.

The result of so many centuries of exploration has been to show that in certain neighbourhoods every scrin, rake, or pipe has been rich in lead, while, on either hand, though similar conditions of structure occur, the same rock has yielded little or nothing. The Alport Mines, for example, were worked in a network of rich veins and scrins, while of the great number of veins running through Elton and Winster nearly all have contained ore; yet in the same rocks for some miles north there has been very little ore found.

The distribution of the gangue minerals (barytes or 'caulk,' calcite and fluorspar) is somewhat erratic. Speaking generally, fluorspar is abundant in the two outliers at Crich and Ashover, and along the adjacent north-easterly fringe of the limestone massif : Messrs. Wedd and Drabble† give reason for believing that it is confined to the uppermost limestones, being replaced in lower strata by calcite and barytes. Elsewhere the gangue may differ widely in parallel veins, or may change laterally in any one lode.

Effects of depth on the lead-ores.—In the superficial parts of the veins, or in the neighbourhood of weathered outcrops, cerussite (white carbonate of lead) sometimes occurs in commercial quantity (Newhaven, the White Rake at Tideswell, Brassington, the Hubberdale Pipe, and at Wicksworth, Winster, and Calver) : at lower levels galena prevails exclusively.

It must be admitted that when followed downwards, the lead deposits of Derbyshire share the common fate of those in other districts; impoverishment in depth is the general rule. As already noted, the driving of the great soughs was, on the whole, attended by disappointment : and there are few cases where one has reason to believe that ore-bodies of any size may still be got

* Stokes, *Trans. Geol. Soc.*, Ser. 2, vol. i, p. 163 (read in 1820).

† *Trans. Instit. Mining Engineers*, vol. xxxv, 1908, p. 501, &c.

below these deep water-levels. The prolonged life of the Millclose Mine, which for over 40 years has been the mainstay of the Derbyshire output, is due more to continued lateral extensions than to progress in depth.

The deepest mines were New Engine, near Eyam (1,092 ft.) and Old End, Crich (912 ft.). These exceptional ventures, along with the workings at Millclose and Ashover, go down to sea-level, or thereabouts : beyond that depth there is no reason to suppose there is sufficient galena to repay the very heavy pumping charges which would undoubtedly be incurred. The prospect of ever finding payable fields of lead-ore in the limestone measures concealed beneath the surrounding coalfields must therefore be regarded as exceedingly doubtful. It may be asked, however, whether there is any reason to expect that galena is replaced in depth by blende, and that in its turn by copper ores. As this has been noted in other areas, attention was directed to the possibility, but unfortunately with a negative result. There is no record of any such change having been observed in the abandoned mines, and at Millclose, although the blende outputs are important, most of that ore comes from the middle levels, and little, if any, from the bottom : nor is there any sign of any tendency for copper ores to come on in depth, although they undoubtedly did so on the western side of the limestone massif, at Ecton, in Staffordshire. At Ashover the little blende got came from a high level, and disappeared as the workings went downwards.

Detailed Descriptions.

The following descriptions of the mines are taken practically *verbatim* from the revised edition of the 'North Derbyshire Memoir,'* enlarged by accounts of the workings in operation at the present time (1919). In that memoir it was found convenient to take the mines in geographical order from north to south. It was mentioned that they had been almost all abandoned, and that the workings were inaccessible. The information concerning them was therefore obtained from such of the managers or working miners as were left in the country, and in some instances from plans. To this was added the descriptions of the mines given by old writers on Derbyshire.

Castleton.

The Odin Mine is referred to by Bray† as being, by repute, one of the oldest in the county. The vein runs W. 10° S., with a slight hade to the south. The displacement of the beds,

* The Geology of . . . . North Derbyshire *Mem. Geol. Survey.* 2nd edit., 1887, p. 128, &c.

† Sketch of a Tour into Derbyshire and Yorkshire, 2nd Ed., 1783, p. 189.

however, if any exists,* must have been nearly horizontal, as shown by the direction of the slickenside on the walls. The vein, running nearly, but not quite along the strike of the beds, starts in limestone at the east end (where it has been 'cut out to-day,' and is still open), and passes westwards under the Yoredale Shale. It was worked in Mawe's time† by levels driven in westwards for more than a mile; the vein varied in width from eight feet to hardly more than four inches, and yielded lead-ore in great quantities with blende, caulk, fluor-spar, selenite, and bitumen. Native sulphur occurred here according to Pilkington.‡

The ore and spar of this mine showed a peculiar property. When one of the surfaces, possessing the grooving and polish known as slickenside, was pierced with a pick, it rent with violence and exploded with a crackling noise. Mawe relates that he saw a man 'when he came out of the mine, only a few minutes after the explosion, who, regardless of the danger, had pierced the sides of this substance, and who was much hurt, and cut violently, as if stabbed about the neck and other places with a chisel.'† The same phenomena have been noticed in some of the Eyam mines and the Gang Mine (pp. 58, 78).

More recently a shaft was sunk on the east side of the high road to a depth of 50 fathoms, and a water-level driven to it from Tricket Bridge, in Castleton. This water-level was carried to a point in the vein 1,250 yards west of this shaft. A line of hillocks, however, points to there having been an old water-level leading down to the brook near the Peakshill, about 700 yards further west again. But there is no evidence of the vein having been found, the cover of shale being probably very considerable.

The Speedwell Level was driven southwards from the foot of Long Cliff in the expectation of intersecting the various rakes which range a little south of west through this hill. It runs at a height of about 700 feet above the sea, while the ground under which it is driven, and where the veins have been worked on surface, rises to between 1,300 and 1,400 feet above the sea. It was anticipated therefore that there would be from 100 to 200 yards in height of each vein rendered workable by the level. The veins, taken in order southwards, are the Long Cliff, the Faucet (or Foreside), the New Rake, and the Dirtlow Rake.

The level was driven at the rate of about a fathom a week, at a cost of 5*l.* a fathom.§ In 1777, according to Bray,‖ 500 yards had been completed, and 400 yards remained to be done. In 1789, according to Pilkington,¶ it was nearly completed.

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* The surface evidence would seem to point to a small downthrow north (*see* North Derbyshire Memoir, 2nd Ed., 1887, p. 41, and Fig. 12, p. 45).

† Mineralogy of Derbyshire, 1802, p. 46.

‡ A View of the Present State of Derbyshire, 1789, p. 174. Farey (*op. cit.*, p. 264) confirms the statement.

§ Camden's Britannia, 1806, p. 434.

‖ Tour into Derbyshire, &c., 1783, p. 218.

¶ A View of the Present State of Derbyshire, 1789, p. 126.

After passing some small veins of spar, believed to be the Long Cliff and the Faucet Rakes, the level reached the New Rake at 750 yards distance from the entrance. The rake consisted of a wide rib of spar, but at the point where the level intersected it, had been completely hollowed out, leaving a narrow but very lofty cavern, extending upwards, probably to near the surface of the ground,* and slanting downwards towards the east further than it could be followed on account of water. The level was driven a further distance of about 600 yards southwards from the New Rake, without, however, any advantage resulting. The rubbish, estimated at about 40,000 tons, was thrown into the chasm in the New Rake without any visible effect. It may be mentioned that if the distances given above (viz., 750 and 600 yards) are correct, the southern end of the level must be about 100 yards short of the Dirtlow Rake. The level has long been used solely as an object of attraction to visitors.

The Red Seats Vein runs east and west at the foot of the limestone hill on the east of Castleton. It has been worked up to the surface, and has yielded much blende as well as galena. The Kitle End Vein, running into it from the south-east, yielded much calamine 35 years ago. The Red Seats Vein may be seen also, with another parallel vein, in the entrance of Peak Cavern. These two are said to be continuous with the Long Cliff and Faucet Rakes.

The powerful vein known as the Dirtlow Rake has been worked from Pindale to Oxlow End, a distance of three miles, in a general direction W. 35° S., with an underlie south. At the east end it was worked under the Yoredale Shale in the Pindale or Ashton's Mine. The shaft was about 50 fathoms deep, with a water-level at 13 fathoms in the shale. A light-grey or greenish variety of the toadstone (or channel) was found to underlie the Yoredale Shale, without any limestone intervening. Threads of ore occurred in the toadstone, but no regular vein was seen. The old engine shaft in Pindale was 40 fathoms in depth, and the Dirtlow Mine 60 fathoms, and the other mines further to the west upon the rake range from 60 to 70, or rarely to 90 fathoms in depth. Near the Hollandtwine Mine the rake divides, one portion running with many parallel scrins through the Hazard Mine (where it has been cut to 100 fathoms depth), and the Portaway Mine to near Watt's Grove, falling nearly into the range of the Coalpit-hole Vein. The southern branch runs through Old Moor Mine, and as far as Oxlow End, under the name of the Oxlow Rake. An engine shaft was sunk about 35 years ago upon it to 50 fathoms depth, but no ore was found. The toadstone was proved at Siggate Head at a depth of 20 fathoms, with a thickness of

* There are many great swallow-holes and such places along the course of the New Rake, marking probably the sites of other underground hollows, the roofs of which have collapsed. It should be mentioned that the cavern is alluded to by old writers as Faucet Cavern. If, however, the rakes were named correctly it must have been in the New Rake as described.

12 fathoms, and near the Hazard Mine at 14 fathoms, the dip of the beds, which is very rapid near the limestone boundary, becoming gentle within the limestone area. It crops out about half-a-mile west of the Portaway and Old Moor Mines, and the engine shaft mentioned above, starting just at its base, was in limestone for the whole 50 fathoms. Good ore was found below the toadstone in the Dirtlow Mine.

There occur along the Dirtlow Rake, the New Rake, the west end of the Moss Rake, and some other smaller veins, a number of isolated blocks of a fine siliceous and cherty rock, or fine grit. The ground south of the Dirtlow Rake and west of Pindale is most plentifully bestrewn with them. The miners state that they are never found in the veins, though they resemble vein-stuff. Yet their distribution is connected with the course of the veins. At the head of Pindale they distinctly occur as a bed in the limestone, and the vast number of loose blocks seem to have been left by the removal of the limestone round them. They seem to have been a very cherty limestone, or in some cases a bed of chert with patches of limestone. As a result of aqueous metamorphism the limestone was removed, and its place taken by a white sand, resulting from the decomposition of chert. The silicification of a limestone has been found in other cases to have depended on the neighbourhood of a mineral vein, as instanced by the walls of the Deep Rake on Longstone Edge, while decalcified limestones ('sandy backs') are often associated with the ore-bodies at Millclose Mine (*see* p. 74).

The Long Rake, about half a mile south of Pindale, runs W. 37° S. No work except "hillocking" for caulk has been done upon it for many years. The Nunlowend Mine, towards the east end of the rake, was working in 1826, and has been quoted as an instance of a vein with ore being prolonged into the toadstone.*

The Slitherstone Mines were worked on a rake running east and west, and forming perhaps the westerly continuation of one of the veins in Hurdlow, but some of the intervening ground is cut up by small parallel scrins, among which it is difficult to pick out any leading vein. The Lower Slitherstone Mine was worked to a depth of 110 fathoms, without the employment of an engine.†

The Coalpit-hole Vein, known in its eastern part as Watt's Groove (or Grove), was wrought about 1887 by the Peak Forest Mining Company, whose agent, Mr. Richard Diness, supplied information at that time.

No. 1 Shaft in Perry Dale is 40 fathoms deep. An extensive swallow hole was met with 100 yards west of this shaft, and took the water from all parts of the the mine above the 40-fathom level. The course of the vein westwards is marked by old open workings as far as the boundary of the Yoredale Shale, close to

* MM. B. de Villiers, Dufrénoy, et de Beaumont. *Ann. des Mines*, t. xii, p. 339.

† The term engine is applied in Derbyshire either to a steam-engine or a horse-whim.

the high road. Here the beds turn quickly downwards, and No. 3 Shaft, barely 100 yards from the road, passed through 30 fathoms of shale, and No. 10 Shaft, 550 yards from the road, through 100 fathoms, before reaching the limestone. The workings were carried a few yards further, the angle of dip decreasing westwards. The absence of the toadstone which was seen at Castleton and in the Dirtlow Rake will be noticed. The direction of the vein is W. 15°–18° N.

Gautrie's Rake, on the south side of the preceding, runs nearly east and west, and joins it at Watt's Grove. It has not been worked for many years.

Bradwell.

Three strong and parallel veins run down to near Bradwell, and are known as the Moss Rake, the Earl (or Ell, or Hill) Rake, and the Shuttle Rake.

The Moss Rake, which hades to the north and has a general range of W. 18° S., has been worked from Bradwell for about $2\frac{3}{4}$ miles westwards. A shaft, known as the Wortley Mine, was sunk on the east of the village through 20 fathoms of Yoredale Shale into the limestone, but missed the lode, which is thought to run further north. On the west side of the village the vein has been worked from the surface down to, and in places below, the water-level. This level is determined by the strong issue from the vein in Bradwell, which is derived both from the west and from the south (Milldam Mine). The Bradwell Co-operative Mining Co. sank No. 2 Shaft, at 150 yards west of the spring, to 18 fathoms depth, and No. 3 shaft, at 500 yards from the spring, to 40 fathoms; and drove a water-level to a point 250 yards west of the spring. Ore was found at 30 fathoms depth in No. 3 shaft. This part of the vein is said to be worked out, but ore was left in the vein west of Outlane Head for want of a water-level. The vein is generally filled with calc-spar in vertical ribs, with prismatic crystals lying horizontally; but a flier from the vein, above Outlane Head, is filled with a thick mass of opaque white rhombic calc-spar, which was being worked for sale in 1887.

The toadstone was reached in all the mines west of Hartle Dale, a steep-sided ravine, under which the rock was found to be 'loose' to a great depth. The Moss Rake was being worked in 1887 at the Rake Head Mine only, near Batham Edge. Toadstone extends from 48 to 50 fathoms, and again from 64 to 70 fathoms in this mine, ore being found both in and under it. At the Silver Cross Mine the ore was stronger below the toadstone than above it. The old open workings in the Moss Rake show the striations and flutings of the slickenside on the walls of the vein to be horizontal, as is so often the case. At its west end the vein seems to split up after intersecting the Cop Rake, which runs nearly west through the Cop and Starvehouse Mines to the Oxlow Rake. Lumps of the siliceous rock described above are

scattered over the ground along the western part of Moss Rake. Bagshaw's Cavern, close to the Moss Rake at its east end, is natural in part only, and is said to have yielded calamine.

The Earl or Ell Rake was last worked, many years ago, in Hartle Dale. The vein is seen in the sides of Bradwell Dale, 300 yards north of Hazlebadge Hall. The vein-stuff seems to have been principally calc-spar in prism-shaped crystals. On the east side of the dale, and between the Earl (or Ell) Rake and the Shuttle Rake, are some old workings on a pipe, which yielded much fluorspar and caulk. Towards the west the Earl Rake dies away in about a mile, but at the same time a nearly parallel vein, known as the Scrin Rake, comes into existence, and, running through the Windy Knoll Mine finally falls into the Shuttle Rake.

The Shuttle Rake has been worked eastwards (though not within memory) at a point 400 yards east of Hazlebadge Hall, whence it runs in a general direction W. 12° S. for $2\frac{1}{4}$ miles; the vein is nearly vertical. It was last worked at the Shuttle Rake and the Intake Dale Mines on the west and east sides respectively of the upper road to Castleton. At the former the depth to the toadstone was about 52 fathoms, and its thickness about 24 or 25 fathoms, the top for 6 or 7 feet being very soft and crumbly. West of the Shuttle Rake Mine the gangue is chiefly calc-spar, but at the Intake Dale Mine fluorspar becomes fairly abundant. A little calamine has been got in the Shuttle Rake, but not enough to sell.

The Chapmaiden Rake was being worked by hillockers in 1887 for caulk. It runs for a short distance only, in a direction about W. 5° S. Farey (*op. cit.* p. 274) states that there were four beds of toadstone in this mine. Nearly in the range of the Chapmaiden Rake, and about half a mile east of Little Hucklow, are some old workings known as the Virgin Mine, in which it is said good ore was left (presumably on account of water). Pilkington states that native sulphur in a layer of 4 inches thickness was found in this mine, and again on Tideswell Moor 1 inch thick; in both cases the mineral (whatever it was) would flame with a candle.*

Much of the ground between Chapmaiden and the western range of Shuttle Rake is overspread by a light heathy soil, resulting from the decomposition of the very cherty limestone from which the siliceous blocks, previously referred to, have been derived.

Tideswell Moor and Eyam.

One of the strongest veins in Derbyshire traverses this district for a distance of about five miles and a half. It is known as the White Rake, Tideslow Rake, High Rake, and Hucklow Edge Rake successively in passing from west to east. It keeps a

* A View of the Present State of Derbyshire, 1789, p. 174, and Farey, vol. i, p. 467.

nearly straight course in a direction W. 5° N., and underlies to the north in its western range, throwing the strata down on this side about 12 fathoms, but is said to underlie south in its eastern part. The vein was discovered some time in the seventeenth century and has been very largely worked, but the mines are now all abandoned, with the exception of the Milldam Mine, where a small quantity of ore was being got in 1887 in the old shallow workings.

The White Rake is so called from the occurrence in it of 'white ore,' or carbonate of lead. It was worked to a depth of 8 or 10 fathoms by the 'old men,'* but has not been touched of late years except in turning over the old hillocks for caulk. The old workings were probably limited to the limestone above the toadstone, which crops out a short distance to the west. Tideslow Rake also has been left untouched for many years. From the upper Castleton road eastwards, however, the rake has been very exhaustively worked to great depths.

At the High Rake Shaft, about a mile and a half N.N.E. of Tideswell, the following beds were passed through.

Section of the High Rake Mine.†

	Feet.
1. Limestone	117
2. Clay	2
3. Limestone	42
4. Clay	1
5. Limestone	117
6. Toadstone, not gone through...	132

In another shaft they sank through 72 fathoms, other accounts say 80, of the toadstone without getting through it, and the attempt was at last given up. Some ore was found in the toadstone in a vein 10 inches thick, according to Pilkington (*op. cit.*, p. 57).

From a quaint old geological work‡ we have extracted the following account of the mines on Tideswell Moor : "On Tideswell Moor, the toadstone, or channel as there called, has been dug one hundred fathoms deep, and no bottom found;

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* This expression is much used in Derbyshire and other mining districts. By the 'old man' is meant any previous worker in the mine. In a country where mining has been conducted on such loose principles, a knowledge of the 'old man's' workings, though of the first importance, is rarely obtainable, and large sums of money have frequently been expended with the result of proving that the vein has already been worked out.

† From a section in the office of Mr. Bagshaw of Foolow.

‡ An Inquiry into the Original State and Formation of the Earth; deduced from Facts and the Laws of Nature. To which is added an Appendix, containing some general observations on the strata of Derbyshire, &c. By John Whitehurst. 4to. *London*, 1778. We are indebted to our colleague, Mr. Whitaker, for the extract.

though in seven other mines adjacent the same stratum has been dug through and its thickness ascertained at each place as under :*

	Fathoms.	
A. Black Hillock	100,	not cut through.
B. Heath Bush	16,	cut through.
C. St. Andrews	2,	do.
D. St. James	12,	do.
E. Constant	7,	do.
F. Calvestones	7,	do.
G. Dunkirk	19,	do.
H. Chapmaiden	17,	do."

If the above account be trustworthy it is not unlikely that the Black Hillock shaft was just on one of the vents through which the toadstone came up; Farey, however, thinks that in the last seven mines Mr. Whitehurst has mistaken some occasional or 'chance' beds of toadstone for the main mass. (Conybeare and Phillips' Geology of England and Wales, p. 450.) There can be no doubt, however, about the fact that in one shaft a great thickness of toadstone was met with, though whether it was got through is perhaps doubtful. Farey (*op. cit.*, p. 274) considered that a sudden outburst of water, which took place at the bottom of the shaft, indicated that the underlying limestone had been touched, but it is generally believed that the toadstone was not bottomed. It may be mentioned here that the toadstone contained many fragments of limestone, differing scarcely at all in appearance from the parent rock. Specimens abound in the hillock.

Near Tideswell the sequence of beds is as follows :—†

	Fathoms.
Surface channel (toadstone)	6
Limestone	6
Channel	$\frac{1}{3}$ to $\frac{2}{3}$
Limestone	8
Main channel	12

The following notes on Great Hucklow, with fig. 5, are taken from the 1st Edition of the North Derbyshire Memoir, published in 1869.

"At Great Hucklow there are two mines at work, one of which by the order of Mr. Moore of Bamford was kindly thrown open to us. The lode runs nearly east and west. A section across the lower part is given in fig. 5. It is a rent 50 yards across at the surface, but narrowing down to 10 yards at a depth of 66 fathoms, filled in with spar or 'kebble,' chiefly calcite, but a little heavy spar also occurs. Embedded in the 'kebble' lie many large detached blocks or 'horses' of limestone and toadstone. Through this broad vein there run narrow, irregular strings of galena, two of which, one near the north and another near the

* The relative positions are shown by a sketch plan in the North Derbyshire Memoir, 2nd Edit., 1887, p. 134.

† As given by Mr. J. Hancock of Tideswell.

south wall, can be worked with profit; here and there a third vein has been worked between the two. The lode is a fault with a downthrow to the north, and at this mine the throw was about 12 fathoms. In the 60-fathom level a clay-parting or ' clay-joint ' a few inches thick was crossed, blue in the upper half and brown below; it was not unlike decomposed toadstone. There is said to be a second ' clay-joint ' below this.

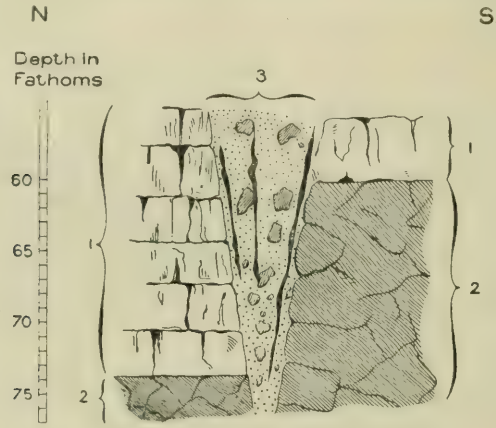

Fig. 5.—Section across a part of the Lode at Great Hucklow.
1. Limestone. 2. Toadstone.
3. Lode filled with ' kebble ' and ' horses ' of limestone and toadstone: the black lines represent strings of galena.

" The top of the toadstone is reached on the south side of the lode at a depth of 62 fathoms, and we were told that the 60-fathom level had been driven to the west beyond the point where they ought to have struck the toadstone, if it had the same dip as the limestone, but that they had not yet met with it. If this really be the case, and if, as there is every reason to think, the toadstone is an interbedded igneous rock, either it must thin out very rapidly to the west, or there must be some cross fault of which the miners are not aware.

" In the 66-fathom level they were working the vein of galena on the south side; it was only an inch thick, but on the day before our visit it had been five inches thick, and it sometimes widens out to three feet. It is interesting to note that here, where the wall is toadstone, the string of galena lies at some distance from it, while higher up, where the wall was limestone, the vein bore best close to the southern cheek. It is also worth notice that whereas in the upper part of the lode the ' horses ' were all limestone, we find here in the neighbourhood of the toadstone wall ' horses ' of decomposed clayey toadstone.

" At the 75-fathom level both walls of the lode are toadstone, but till the workings have been pushed on farther it is impossible to say how the vein will bear here.

" The toadstone is an amygdaloidal rock, as is very beautifully shown where it has decomposed into a soft friable clay. For by

washing this, or merely rubbing it between the hands, one may pick out the small rounded or almond-shaped kernels of calcite, which once filled the cavities in the vesicular rock. These pieces of calcite are coated with a green mineral (probably delessite), and the rock thus acquires a speckled look, showing green spots on a yellowish brown ground."

Little or nothing can be added to the foregoing account, published over fifty years ago, for no work has been done at Great Hucklow for very many years. The diagram (fig. 5) clearly shows how the rake narrows in depth. It is probable that the workings at the 75 fathoms level were unsuccessful, and that, in common with so many others in Derbyshire, the lode died away in the toadstone to a mere fissure, of no economic importance.

It will be seen by the map that at the Milldam Mine the lode passes the boundary of the Yoredale Shale. The Pumping Engine Shaft proved the following section :—*

	Fathoms.
Black shale	5
Limestone	70
Toadstone	—
	75

At the Smithy Coe Shaft, 250 yards further east, the shale extended to 24 fathoms depth, and in Shuttleworth's Shaft to 50 fathoms, the total depth of working being 82 fathoms. There the vein runs nearly along the strike of the beds, and the depth to the limestone in the Silence Shaft (1,200 yards east of Milldam) was 54 fathoms 4 feet, the shaft being carried 33 fathoms further in limestone. The most productive ground was found generally at 25 to 40 fathoms below the base of the Yoredale Shale.

A little west of the Smithy Coe Shaft the vein throws off a branch on the south known as the Sun Vein; the two are believed to unite again further east. Near the New Edge Mine a branch was thrown off on the north side which ran to Little Milldam Shaft, and the ownership of which was long disputed.

One hundred yards east of the Silence Mine is the Old Grove Shaft, near which a vein branches off in a north-westerly direction. It has been worked at the head of Bretton Clough in the Back o' the Edge Mine, and in a level, known as May Sough, on the west side of the grit hill.

The succeeding mines are the New Grove, Slater's, Black Engine, and Middleton, all of which have been long disused. At the last named the vein divides again, one branch running south of east through the Old Twelve Meers Mine, the other more nearly east through Twelve Meers, Broadlow, Lady Wash, and New Engine Mines. In 1746, after a great lawsuit, during which much evidence as to the character of the veins was taken,

* The information concerning these mines was supplied by Mr. Leonard Maltby of Great Hucklow.

it was decided that the more northerly of the two was the continuation of the great Hucklow Vein, one of the points being that it underlay south. The Hucklow Vein underlies south at the Silence Mine also; there would appear, therefore, to be a change in the direction of the hade between this mine and Milldam.

The Broadlow Mine has long been abandoned, but the Lady Wash and the New Engine shafts were in work at a later period. Both were started in the grit, and sunk through into the limestone; the former, which was 156 fathoms deep, reached the limestone at 132 fathoms 4 feet. In sinking through the shale, a bed containing rock-oil was encountered. The oil occurred in bands of a honeycombed but intensely hard rock, resembling melted iron, and about six to eight inches thick; the rock was known as 'cauk' (? coke).

This part of the vein is unwatered by Stoke Sough, a level driven from the Derwent 500 yards north of Stoke Hall, for a distance of about $1\frac{1}{4}$ miles, at a cost of 35,000*l.* (Farey, *op. cit.*, vol. 1, p. 330). The depth to the sough at the New Engine is 131 fathoms; the mine, which had been abandoned after slightly exceeding this depth, was carried, by the help of improved pumping machinery, to the greater depth stated about the year 1860. The sough is said to terminate at Lady Wash. In Eyam Registry there are records of men having been killed in Stoke Sough in the years 1732, 1734, and 1778, probably through explosions of fire-damp (Farey, *op. cit.*, p. 333). The water from this sough was warm (*ib.*, p. 505).

The Black Hole Vein runs a little south of west from Highcliffe to the great chasm known as Waterfall. It was worked in the Black Hole, and the Little Pasture Mines, at the latter to a depth of 42 fathoms.* At Waterfall it intersects the Cross Low Vein, which runs through Foolow to the west, and to Dustypit Mine to the east. At Dustypit the Cross Low Vein divides into three; the Dustypit vein,† a close hard and black vein, on the

* As stated by Mr. J. Hancock of Tideswell. A level was driven along the top of the limestone from this mine at 30 fathoms to Twelve Meers. Fluorspar occurred in Little Pasture Mine.

† This vein runs to the Highcliffe Mine, where a curious phenomenon was observed. The vein was traversed by divisional planes, parallel to the walls, and polished and grooved in the manner known as 'slickenside.' On being struck or even scratched by a pick a crackling noise was heard, and was, after a short pause, followed by an explosion, often most violent in its effects. A great explosion is described by Whitehurst (Formation of the Earth) as having occurred in 1738, and the phenomenon is referred to by nearly all writers on Derbyshire in the last century. It appears even that the mine was abandoned for a time on account of the danger, but that the miners subsequently learnt how to take advantage of the peculiarity in getting the ore. Such explosions, as I am informed by Mr. Maltby, are still liable to occur on a smaller scale in the neighbouring mines; they may be attributed to the mineral (chiefly barytes) being under pressure. The removal of support from one side of a vertical sheet of spar bounded by two planes of slickenside leaves such a sheet in a condition to fly to pieces at the slightest shock (*see* also p. 49, Odin Mine, and p. 78, footnote, Gang Mine: and A. Strahan, On Explosive Slickensides, *Geol. Mag.*, dec. iii, vol. iv, 1887, p. 460).

north; the Cross Low, a soft, 'sludgy' vein with caulk, in the centre, and a vein with fluorspar, and very rich in ore, on the south. At the Dustypit shaft the following section was proved :—

	Fathoms.
Yoredale Shale	2
Limestone	60
Toadstone, amygdaloidal	1+
	63

The vein was worked for some 300 or 400 yards in a south-easterly direction, and proved extremely profitable. The ore, which lay in two ribs, and was worked at small expense, occurred above the toadstone, and from 30 to 40 fathoms below the top of the limestone. The vein was impoverished in the immediate neighbourhood of the toadstone.

A little blende was seen in Lady Wash Mine, but with this exception zinc-ores have proved very scarce throughout this neighbourhood.

The mines in Eyam were drained by the Moorwood Sough, which runs from Middleton Hall through the Cliff Stile Mine, and under Eyam (150 yards east of the church), to a point about 400 yards short of the Highcliffe Mine. It appears to have been commenced about 1750, but twice abandoned before reaching the point stated.

The Watergrove Mine was on a very heavily watered pipe-vein near Wardlow Mines. It was abandoned about 1850. The run of the pipe is said to have been extremely irregular, both in depth and direction. The mine was drained to a depth of about 45 fathoms by a level opening into Middleton Dale, about a mile above Middleton. An outlier of Yoredale Shale occurs at Watergrove, proving the limestone to be the top bed; the beds undulate considerably, as may be seen on the surface.

On Middleton Moor there are many old workings, chiefly along the Cliff Stile Rake, which runs about W. 20° S., and a cross vein running about south-east. The mines have been long abandoned except by hillockers in search of caulk.

The Seedlow Rake runs nearly east and west through Wardlow; west of this village, it takes the name of the Sough Vein, presumably through the existence of a sough into Cressbrook Dale.

Calver Sough is driven from the dam of Calver Mill north-westwards; the engine shaft upon it was sunk to a depth of 25 fathoms and abandoned.

Longstone Edge.

The master-vein of this tract is known as the High Rake and the Deep Rake (or Longstone Edge Vein) in its west and east ranges respectively. At its west end it crosses Cressbrook Dale, but can be better seen in the spar workings on the road from Monsal Dale. It runs nearly due east with a hade to the north,

and is double, with much white calc-spar, and having the appearance of a strong fault. It may be traced thence by old workings for about a mile and a half to a point where it bends to the north-east, and takes the name of the High Rake; here in 1887 it was being worked for caulk. Resuming its easterly course it becomes the Deep Rake, and has been worked by means of a level driven into it from the Sallet Hole Mine,* in Combs Dale. Toadstone was found at 60 fathoms depth, and was cut into for 10 fathoms to reach the depth at which the level entered the vein. The rake was in many places 14 yards in width, as it must also have been on the surface, judging from the great size of the old open workings along all this part of its course. Caulk was abundant and fluorspar may still be seen adhering to the walls. Further east the limestone forming the walls of the vein has been highly silicified and has been worked for chert.

The Crossdale Head Mine is situated about 70 yards south of this vein near its west end, and between it and a vein running south of east along the slope of the hill, also a fault with a down-throw north. The shaft was about 60 fathoms deep and reached the toadstone; the veins are said to be cut down to this rock. The south-easterly vein divides into two further east, one branch running along the brow of the hill to the Hard Shaft (which was sunk to the toadstone at 50 fathoms depth), the Hard Piece Mine, the White Coe Mine (50 fathoms), and so into the Deep Rake; the other branch known as the Ox Pasture Vein, ranging into the low ground through the Ash Nursery Mine, (between 40 and 50 fathoms), the Ox Pasture Mine (30 fathoms), and the Blue Bell Mine (40 fathoms), east of which it becomes the Tor Vein, which was worked in the Waterhole Mine (sunk to 40 fathoms without touching the toadstone), and in the White Coe Mine.

The Harrybecca, Brightside, Backdale, North Cliff Sough, and Red Rake mines have been worked upon a series of rakes and scrins which run down the hill-side in a general easterly direction towards the Yoredale Shale. The Harrybecca Mine was about 40 fathoms deep, on some scrins which may be seen in old open workings 200 yards to the west. The Brightside Mine was 51 fathoms deep and was drained to a depth of 40 fathoms by a sough opening in Calver village. It was worked upon a great number of scrins, ranging from two to three inches in width and sometimes filled with solid galena. The scrins were divided into 'plumbs' and 'hadings,' the former being vertical joints, the latter apparently partings between beds of limestone, which here dip south-east at about 45°.† The greatest yield in one year was 511 tons. The Backdale Mine was on a southern branch of the Deep Rake. The vein was reached by a cross-cut

* The information on this and the succeeding mines was supplied in 1887 by Mr. William Bland, of Eyam.

† The dip on the top of the hill is about 10°, but becomes steeper towards the Yoredale Shale, as is often the case.

driven about 100 yards into the hill from the bottom of the shaft, at 40 fathoms depth. The toadstone, rising with the beds, was touched in the north end of the cross-cut. The hillock has been turned over for fluorspar. The North Cliff Sough was driven into the hill-side in a westerly direction in the year 1853. Here also fluorspar has been picked out of the hillock. The Red Rake is a stronger vein branching from the Deep Rake on its north side. It was worked in the Muse Mine and in the Red Rake Mine, which was 20 fathoms deep, with levels to the vein both on the surface and at the bottom of the Shaft. The Red Rake Mine was re-opened in 1907 by Messrs. G. Blackwell & Sons, and subsequently continued by the Grove Syndicate, till it was closed early in 1919. The level at the bottom of the shaft was extended westwards and an incline driven, which was stopped in a ' pinch ' 13 yards below. The vein was from 1 to 6 ft. wide in irregular ' bellies ' mostly filled with fluorspar, galena being in poor quantity. At the same time work was done from the high level, which starts in shale, immediately east of the shaft mouth, meeting limestone within a distance of 60 yards. From this high level most of the ore was got ; it was driven along Red Rake up to a couple of cross-veins, Hog Rake and Catlow Rake. Hog Rake inclines W., and was usually very thin (up to 1 foot across) but with at least one rich pocket of ore. Catlow Rake was also thin (up to 18 inches wide) but carried good ' bellies,' or rather ' flats ' along the bedding planes of the limestone walls. One of these ' flats ' was 22 feet wide and about $2\frac{1}{2}$ feet high. Additional access to the subsidiary rakes was obtained from a level cross-cut starting at North Cliff Sough Mine, a little higher up the valley.

The workings were fairly dry in summer, but in winter time there was much water, up to 250 gallons per minute.

Monsal Dale.

The Putty Hill Vein, running about W. 20° S., was formerly worked for galena and calamine, but is now utilised only as a source of white-spar. Above Litton Mill a vein with the same direction has been worked open-cast. It shows horizontal slickenside on the walls, and a pipe that has been partially excavated close by can be explored by day-light. It is lined with concentric layers of calcite, the prism-shaped crystals of which are arranged radially in the pipe. At the Moorhigh Mine a good deal of brown as well as some white ore was raised in addition to galena. Ore was got there in the toadstone (Farey, vol. 1, p. 262, Maury Mine).

Taddington.

The Glory Mine was worked about 1887 to a depth of 30 fathoms in a rake running in a general east and west direction and hading to the north. The shaft was started in the first

toadstone, but for the greater part is in limestone. The Groove Rake, running W. 25° S., towards Chelmerton, has not been worked of late years.

A mile south of Taddington lie the few hillocks which mark the site of the famous Hubberdale Mine, which was one of the richest mines in Derbyshire about the beginning of last century. A lump of galena weighing ten tons was found here about 1768.*

The ore was obtained in a pipe-vein, running a little west of north, and said to have been 150 yards broad. The mine was drained by a level driven from Deep Dale along a rake under Nether Wheal and intended to unwater the Wam or Groove Rake.† The Hubberdale pipe was intersected accidentally, and worked, it is said, with a profit of 17,000*l.* a year for seven years, though the upper part had been previously got by the 'old men.' The level enters the pipe (which runs nearly horizontally) at 46 fathoms depth. There was much white sand in the pipe, and iron-ore was associated with the galena; the latter was picked out in large lumps and required but little washing. Between Hubberdale and Deep Dale are many small scrins.

Sheldon, Monyash, and Over Haddon.

The following section of the Dirtlow Mine, near Sheldon, was copied from an old plan in the office of Mr. Bagshaw of Foolow.

Section of the Dirtlow Mine.

	Feet.
Black limestone ... } 'Channel' toadstone }	90
Black limestone	60
'Channel,' irregular in thickness.	
White limestone, thickness not given.	
'Channel,' not cut through.	

This is valuable as proving the existence, here at least, of *three* beds of toadstone.

The rake runs W. 18° N. on the north side of Sheldon; it is not now being worked.

The Magpie and True Blue Mines are situated on a vein running W. 15° N. on the south side of Sheldon. They are both old mines, Magpie being still (1919) in work, though True Blue has long been abandoned.

Magpie Mine.

(From observations made in 1919.)

Owners.—Messrs. C. Garlick & Sons, Lynx Works, Sheffield.

Site.—Half-a-mile S.S.W. from Sheldon Church.

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* A. H. Stokes, Lead and Lead Mining in Derbyshire, p. 73.

† There is said to be another level running a little west of north towards the Waterloo Inn. This was probably to unwater the older workings. The information concerning this mine was derived from an old miner.

History.—This is an old mine, where the workers, long ago, had a notorious struggle with their rivals from the adjacent True Blue Mine.* It was worked by Mr. Wyatt of Foolow, and some Cornishmen, up to 1846, under the name of the 'Magpie' Mining Co. The mine then lay idle until 1868, when it was resuscitated. A water-level, 1 mile long, to the River Wye was begun in 1872, but not finished until 1884, in which year the shaft (which is cut by the level at 95 fms.) was deepened from 114 to 120 fathoms. Since that date the mine has been intermittently wrought, and of late years has been opened out considerably by Mr. Garlick, particularly as regards the 92-fathom level, which has been carried under the site of the True Blue Shaft, $\frac{1}{3}$ mile to the east.

Geology, &c.—The main lode is known as the *Bole Vein*; it runs about E. 20° S., dipping steeply to the N. Small parallel fissures, known as the Magpie and Shuttlebank Veins are found a few yards away to the S. These veins are, in the main, thin and relatively unproductive, but expand at intervals into irregular swellings or 'bellies,' from which most of the ore has been got. These cavities yield up to 50 per cent. galena, the vein-stuff being calcite, with a little quartz and fluorspar, but no caulk, pyrites or blende: they are connected by 'live' (*i.e.*, galena-bearing) strings an inch or less across. One exceptionally large chamber, known as 'Chatsworth,' was about 60 yards long, 20 ft. broad, and 15 ft. high: it was found close to the shaft just below the 95-fathom drainage level, and further ore-bodies have been got below it, whose continuation in depth still remains to be proved.

The shaft is 120 fathoms deep: it is said to pass through the Ashford Black Marble, from 30 to 80 fathoms, and is in the Bole Vein from 70 to 100 fathoms. Six levels have been driven off, at 52, 68, 92, 102, 114 and 120 fathoms: of these, the chief one is that at 92 fathoms, which has been driven on the Bole Vein for 180 yds. to the W. and 600 yds. to the E., under the site of the old True Blue Shaft, and in this direction the vein was found up to 6 ft. wide, much of it filled with clay, but containing small 'bellies' of ore, in a calcite matrix. East of True Blue the vein-stuff appears to change to caulk, of inferior quality, as may be seen in the surface workings near the site of Magshaw Mine, at Bolehill Plantation.

It is of interest to observe that at the E. end of the 92-fathoms level a rise, 85 ft. high, was driven up under the site of the True Blue Shaft, and ended in toadstone. No such rock was got in the Magpie Shaft, although as the strata are practically horizontal it ought to have been got at about 80 fathoms, and it seems clear that the igneous rock dies out in the comparatively short interval between the two shafts.

The water-level from Magpie Mine to the River Wye, offers several features of interest. This level, 1 mile long, was driven

* See North Derbyshire Memoir, 2nd Ed., 1887. p. 141.

from the river towards the mine : it is about 6 ft. high, and was in toadstone until it cut the Fieldgrove Vein about 300 yds. N. of Sheldon village : this vein, judging from old workings, seems to have yielded lead near the surface, but as cut in the level (where it was 6 ft. wide and 80 fathoms below ground) it was filled with calcite only. Further on, directly under the village, a fissure 8 feet wide was struck, with 6 feet of calcite on the S. side, the remaining 2 feet being open : a very heavy feeder of water was encountered here, and still pours into the level freely. South of Sheldon, and 600 yds. from the shaft, a series of cavities was met with in the limestone : these were filled, wholly or in part, with calcite, interbanded with blende, galena being absent : much of the calcite is in well-formed 'dog-tooth,' and 'nail-head' crystals. Some working has been done here, about 40 tons of blende having been got, besides a certain amount of white 'spar.' There seems to be no definite vein, but at the surface, 83 fathoms above, the site of an old 'lead mine' appears on the Ordnance map, so that it is possible that we have here an instance of the replacement of galena in depth by blende, though it is noteworthy that in the Magpie mine itself no blende has been got, even in the deepest, or 120 fathoms, level.

The Bole Vein, when cut by the level close to the shaft, had pinched out to a calcite stringer, an inch or less thick.

The mine is somewhat heavily watered, an average of 800 gallons a minute being pumped into the drainage level and for this reason the workings have been kept above the level as far as possible. The bottom, or 120 fathoms, level has not been much developed, and only extends some 50 yards on either side of the shaft bottom. Nevertheless, it has given good ore, and in places bodies of galena, 11 inches across, are said to be left intact in the sole of the workings. It is evident, therefore, that in spite of the depth of the mine, considerable reserves of ore may still exist below the present workings.

The output being very small at present, the treatment of the ore at the surface is somewhat primitive. After washing, it is passed through a jaw crusher, and subsequently through a couple of hand jigs or 'hotches.' Transport is by road to Bakewell station (M.R.) 4½ miles away.

The Hard Rake lies about one mile west of the Magpie Mine. It runs about W. 14° N., and is accompanied by many parallel scrins, most of which contained calamine; a cross-joint running towards the north is said to have contained a rib of calamine 20 inches wide. This ore was being picked out of the hillocks of the Hard Rake in 1887. The Hard Rake shaft was sunk to the water at 50 fathoms depth.

The Mandale Rake, which is said to have been one of the first worked in Derbyshire, is first seen on the south side of the Hard Rake, but it has not been continuously proved further west than the Monyash and Ashford Road, whence it runs E. 30° S., and

curving to E. 22° S., to Over Haddon. The principal work upon it was at the east end, where a shaft was sunk 22 fathoms below the level of the Lathkil, and the Old, Middle, and Bottom levels driven up the vein, the mine being pumped by a waterwheel (52 ft. in diameter) by the riverside. Old Level was over a mile long, but the other two only half as far. The vein appears to have been along a joint plane, and, with the use of efficient pumps, may yet produce much ore below the level of the old shallow workings.

The Haddon Grove, Small Penny, Little Mycross, New Rake, and Greensward Rakes are more or less parallel to the Mandale. On the last named a shaft has been sunk to 60 fathoms depth, and a pumping engine put up. The Ashford Black Marble is said to occur here at 52 fathoms depth. It will be seen therefore that the mines described above are in the upper beds of the limestone, though situated in the centre of the limestone area.

Alport and Youlgreave.

The strongest vein (though not the richest) of this district is known as the Long Rake, the Ladies Vein, or the Black Sough. It has been worked continuously along the road on the north side of Middleton Common, where it runs nearly east.

The Long Rake Spar Co. have a mine on the vein hereabouts, worked intermittently. The shaft is on the roadside $1\frac{3}{4}$ miles W. of Youlgreave Church ; it is 46 fathoms deep, at which depth water is met with and the workings (which are primarily for spar) stop. The rake can be seen in old opencasts, and is in two leaves, each about 3 feet across, with a 6-foot ' rider ' of limestone between ; both divisions are filled with a massive opaque white calcite. The vein-stuff passes through roller crushes, after which the little galena obtained (never more than 3 or 4 tons a year) is extracted by a hand jig or ' hotcher.'

East of this working, the vein is said to make for Coalpit Bridge, but for nearly a mile there is no surface evidence of its presence. At this bridge a strong vein, or fault, is seen running in a straight line for Fillyford Bridge, with Yoredale Shale thrown down on its south side for a large part of the distance, whence it takes the name of the Black Sough. The throw is said to be from 20 to 30 yards down to the south, but the vein hades, in parts at least, to the north, and is therefore a reversed fault.

The Mill Green Shaft, near Coalpit Bridge, was sunk to a depth of 14 fathoms, the pumps being worked by a water-wheel, and was then drowned out. At the intersection of Wheel's Rake with the Ladies Vein there is an old shaft down to the water-level. The toadstone is 17 fathoms thick, and is thrown down 10 fathoms to the south, though the vein hades decidedly to the north.* On part of the same vein the shale was found to be 20 fathoms thick on the south side and $5\frac{1}{2}$ on the north, giving $14\frac{1}{2}$ fathoms

* From information by Mr. William Garrett, of Alport.

as the throw of the fault; here again the hade was stated to be to the north.*

The Ladies Vein forms the northern limit of the famous Alport mining field, which has been one of the richest in Derbyshire. Though several of the veins have been worked up to their intersection with the Ladies Vein none have been known to cross it.†

The veins in this field are separable into two sets, having an average direction of about north-east and north-west respectively, but the mineral contents seem to have been much the same in both. It may be noticed, however, that in the old plans the terms pipe and cross-vein are usually applied to the north-east system, while vein and rake are applied to the north-west.

The district is heavily watered, and, as the shallower deposits of ore were worked out, soughs were driven from time to time to relieve the deeper parts of the veins. The following note on the progress of one of the earlier soughs is taken from an old plan in the Alport Mining Office, 'March ye 29th, 1718. Forfield of Alport Sough was in the Cathole Vein. The taile was in the river Lathkil where crossed by the Sough Vein.' The Cathole Vein crosses the river 400 yards above Alport Bridge, and the Sough Vein (now known as the Wheel's Rake) crosses 700 yards below the bridge, measured in a direct line. Later, a sough was driven from North Rainstor to a bend in the river 540 yards west of Fillyford Bridge.

The Hillcar Sough runs from the Derwent $1\frac{1}{2}$ miles south of Rowsley, under Stanton Moor to a point about 300 yards north-east of Nine Ladies, thence to the Brown Bank Shaft by the side of the brook 400 yards north of Eagle Tor, from which it turns north-westwards to the Old Engine Shaft 400 yards west of Greenfield.‡ Up to this point, $2\frac{1}{3}$ miles from the entrance, the sough was navigable, and from here branches were driven in various directions. The sough was 40 fathoms below the surface at Guy Shaft, about 330 yards north-east of the Old Engine Shaft (or 33 below the river at Alport), and was about 13 fathoms down in the limestone, below the base of the Yoredale Shale.§ From near Cow Close a branch $1\frac{1}{4}$ miles in length, and known as Thornhill's Sough, was driven to the Wheel's Rake. The flow of water from the sough was estimated by Mr. Stokes in January 1880, to amount to 15,000 gallons a minute.‖

A rock called Rhienstor, overhanging the river Bradford, 400 yards above Alport Bridge, has the date 1753 cut upon it, which is supposed to have been done on the completion of the Hillcar

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* By Mr. Henry Toft, of Alport, Secretary to the Alport Mines.

† With the possible exception of Bowers Vein, on the line of which, on the north side of Ladies Vein, are a few old shallow workings. The vein seems to have been shifted 10 or 15 yards eastwards on the north side of the Ladies Vein.

‡ This course is given on an old lithographed plan of the sough in the Alport Mines Office.

§ From Mr. Henry Toft.

‖ Lead and Lead Mining in Derbyshire, p. 46.

Sough. But Bray (Tour in Derbyshire, &c., p. 219) writes that the sough was in progress in 1783, scarce a third of it being done, at a cost of 10,000*l.*, and Pilkington, writing in 1789, states that "20,266*l.* 12*s.* 1*d.*, exclusive of interest, have already been expended upon the Hillcar Sough alone" (View of the Present State of Derbyshire, p. 126), after remarking that the sough (referred to as a very large sough at Youlegreave) is nearly completed. Mawe (*op. cit.*, p. 52) gives the cost at 50,000*l.*, and Farey remarks that boats were used in it (*op. cit.*, p. 330, 1811). Mr. Stokes (Lead and Lead Mining in Derbyshire, p. 46, 1880) states that it was commenced in 1751 and took 21 years in driving. According to others it was begun in 1732 and completed in 1753, as before stated. It is possible that the date cut on Rhienstor is the date of the commencement of the sough, if it has any reference to it at all.

The north-west veins, taken in order from east to west, are Seller's Vein, Bowers, Milking Spar, Wheel's Rake, Ditch Rake, or Caslow or Habnab Vein, Cobbler, Abbot Holes, Sutton, Cathole, Danger, Old Leewall, Guy, Bacon or Bacon Close, Marshall or Pyenest, and Wenley Hill Veins.

Bowers Vein may be seen in old open workings on the north side of the road; it runs E. 43° S. Seller's and Milking Spar Veins have been worked for a few yards only.

The Wheel's Rake runs in a general direction E. 47° S. and is a fault with a downthrow to the north-east of two feet. The Wheel's Rake Shaft on the south bank of the river was sunk through the following strata :—*

	Fathoms.	Feet.
Top limestone	8	4½
First toadstone	13	4½
Limestone	7	3
Toadstone (bored into)	56	—
	85	0

This rake was last worked about 1887 north of the river. The Engine Shaft in the wood was sunk to the top of the first toadstone at 27 fathoms depth, the Hillcar Sough taking the water down to this level. The toadstone was light-coloured, soft, and amygdaloidal at the top, but became harder and darker below. The galena was associated with caulk and brasil (iron pyrites); some brown ore occurred. The Wheel's Rake Engine Shaft, 170 yards south-east of the junction with the Ladies Vein, was sunk to 48 fathoms.†

Towards its southern end the Wheel's Rake divides into the White Rake, Amos Cross Vein, and Hilton Vein, which, however, keep close together.

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* The measurements are from an old section of the shaft in the Alport Mines Office, excepting that of the boring, which was supplied by Mr. Toft.

† From Mr. William Garrett, of Alport.

The Sutton Vein has been worked in the Black Shaft, the Nicker Tor Mine, Taylor's Shaft, and the Broad Meadow Engine Shaft. The last named intersected the toadstone at 21 fathoms below the Hillcar Sough. According to an old plan in the possession of Mr. Evans, Barmaster to the Duke of Rutland, some good ore was left in the bottom level, which could not be fully wrought in old times owing to water trouble. The Abbot Holes Vein, which falls nearly into the range of the Sutton Vein, crosses close to the junction of the Lathkil and Bradford. The Cathole and Danger Vein, and two east and west pipes, known as Croke Pipe and Hartle Dale Pipe, are seen crossing the river on either side of Rhienstor. The Old Leewall and Guy Veins are parallel veins about 50 yards apart. The workings in the Guy Shaft were carried 20 fathoms below the Hillcar Sough, which was at 40 fathoms depth. The Bacon Vein was worked out to 16 fathoms below the sough, but below this ore was left on account of the strength of the water; there was some blende. The Pyenetnest Shaft is 50 fathoms deep. This vein intersects the Black Shale Vein, which runs W. 10° N., at the Crashpurse Shaft, close to the reservoir. The old Engine Shaft, at which the Hillcar Sough terminates, was on the Great Shale Vein, a barren vein. The sough here is 4 feet below the top of the limestone.

The north-easterly veins have also proved very rich. The Hillcar Sough is said to have been originally intended to unwater the Old Cross Vein, which crosses the Guy and Old Leewall, and runs to Broad Meadow. This vein was drained by the Shining Sough, which emptied itself into the river near Wheel's Rake Shaft. The Clay and Clark's Cross Veins cross the Bacon Vein and Guy Vein. Corton Hill Pipe runs along the south side of the river by Youlgreave. Hardwork Vein and Blythe Pipe cross the Wheel's Rake in the bank of the brook from Eagle Tor. The Sough Vein and Birchover Vein cross the same brook further south. The North Rainstor (? Rhienstor) Vein runs from the north side of Harthill-hall Farm down the valley of the Lathkil. Besides these there are many smaller veins, the shallower parts of which have been worked.

For the last 30 years the only active working in the district has been on the Wenley Hill Vein, at Mawston Mine, south of Youlgreave. The following account of this undertaking is founded on notes made in 1919.

Mawston (or Mosston) Mine.

Owners.—The Bradford Vale Mining Coy., Matlock.

Site.—The Mawston shaft is 1,060 yds. due S. from Youlgreave Church.

History.—The mine seems to have been first worked from the old Wenley Hill shaft, in Wenley Hill Plantation. In 1878 the Mawston Mining Coy. was formed : in that year they sank the present Mawston Shaft, and in 1882 arranged with the Alport

Mining Coy. to drive a waterway to the Hillcar Sough (owned by the Alport Coy.). After that date the mine was wrought at intervals, on a small scale, until January 1919, when the Bradford Vale Mining Coy. was formed, and took over the mine, which is now being actively developed.

Geology.—The Wenley Hill Vein, on which this mine is situated, trends E. 35° S., with a steep dip to the N.E. The country rock is massive cherty limestone, covered by shales, the whole dipping S.E. at about 10°; the limestone is well exposed in Bradford Dale, while the shales ' take on ' at Wenley Hill, and are 26 fathoms thick in the Mawston Shaft.

The vein, as now seen in the bottom level, is somewhat ' lean ' and ' dry,' about a foot wide, and filled with a soft dirty caulk with strings of galena, between hard limestone walls. Some of the old workings are as much as 4 feet across, but this seems to be exceptional. On the sole of the bottom level (34 fathoms) at Mawston, there is a rib of galena 1 to 3 inches broad, now being worked; the mineral is coated with an amorphous black deposit, which on analysis proved to be sulphide of lead, and is doubtless a re-precipitation of secondary origin.

Mining.—Mawston Shaft is 34 fathoms deep, the upper 26 fathoms being in shale. Three levels have been driven from it, the first at 22 fathoms, connecting with the Wenley Hill shaft, the next a couple of fathoms below, and the third, or bottom level, at 34 fathoms. From the bottom level, at a point midway between the shafts, a drainage level has been cut to the N.E., joining the Hillcar Sough close to the old Pyenetnest shaft; it was driven on the Clay Vein, and in the process enough ore is said to have been got to pay for the cost of the work.

Active developments are now proceeding (1919) and new machinery has been installed. It is hoped that an extension of the workings in depth will find the vein both wider and more productive in the massive white limestone, than it is in the upper cherty beds, to which previous operations have been confined.

The ore-dressing and transport arrangements had not been completed at the time of our visit (1919). The nearest railway station is at Great Rowsley (M.R.), 4 miles away.

Winster and Elton.

This district, which has been very productive, shows some points of similarity with the last described. The lodes are productive in the same beds, namely, in the uppermost limestone (with some exceptions hereafter mentioned); they run generally in a north-westerly direction, and they are cut off to the north by a fault which is known as the Coast Rake, and ranges nearly parallel with the Long Rake or Ladies Vein.

The district (with the exception of the west end of the Coast Rake, from which there is a sough into Gratton Moor Dale) is drained by the Yatestoop Sough. The original sough, known

as the Lousey Level, had been driven from the bottom of the valley 500 yards north of Winster to the Will's Foundry Mine, 300 yards north-west of the church, and thence into the Portaway lode, at a point nearly south-west of the church, finally terminating in the Whitelow Rake. The Yatestoop Sough was driven from the banks of the Derwent at a point 900 yards above Darley Bridge, under Warren Car, to a shaft 300 yards west-north-west of Sabinhay Farm. Thence it runs to a shaft 200 yards south of Upper Town. At White Holme Farm it enters the Coast Rake, up which it is continued, its length from the river to the first working on the Coast Rake being about 100 yards short of two miles. It was 21 years in driving and cost upwards of 30,000*l.* (Farey, vol. 1, p. 331); it was probably begun about 1743 (*postea*, p. 72).

The Coast Rake runs E. 14° N. from Gratton Dale, almost under Elton Church, to White Holme, from which it is sometimes called White Holme Rake. It has been worked principally east of Elton. There is a deep shaft 50 yards east of the church, and near its intersection with the Portaway Vein the Coast Rake is said to have contained blende and the variety of galena known as steel-ore. A shaft on the north side of the rake was pointed out as being the most northerly working in the Portaway Vein. With this exception the Coast Rake cuts off all the Elton and Winster veins. It appears to be a strong fault with a downthrow north.

The general direction of the Elton and Winster veins is about N. 20° W. A great number of scrins, nearly all of which have been worked, run down the hill west and south of Elton. The principal of them is the Whitelow Rake,* which runs from a little south of Leadmines Farm to near Shothouse Spring. It has been worked both above, in, and below the toadstone. In the limestone above wad was being raised in 1887; near the high road a shaft was sunk in the toadstone to 25 fathoms depth, getting good ore in this rock. Three hundred yards south of the road, in a shaft at the termination of the Lousey Level, the toadstone was bottomed at 40 fathoms, and 150 yards further south at 12 fathoms. It would appear therefore that there must either be a very rapid thickening out of the toadstone here, or that a mass of it has fallen into the rake. The Lead-Mines Vein falls nearly into the line of the Whitelow Rake; it has been worked to a depth of 35 fathoms at Elton and to 40 fathoms at Lead-Mines Farm without reaching the toadstone. The Dirty Face Shaft, 200 yards to the south-east, was 50 fathoms deep, all in limestone. The series of parallel scrins, known as the Lick Penny Veins, bore ore in the toadstone.

The famous Portaway Vein was worked at its most southerly point at the Little England Shaft (6 fathoms deep) near the Winster and Newhaven road. At the Buckdale Shaft, near the bend in the Bakewell and Ashburn road, it was worked to about

* Not the vein running E.N.E. across Bonsal Moor, alluded to by Farey as having yielded much calamine (*op. cit.*, p. 269).

50 fathoms depth, or about 20 fathoms below the Lousey Level, by the assistance of old-fashioned pumps. At Hey Spot Shaft it yielded green ore and caulk. Next is the Portaway Mine, at which nothing can be seen now but the enormous hillocks, and the Elton or Coast Rake Mine, from which the vein was reached by a cross-cut, 40 fathoms in length. Farey refers to this vein as having yielded much lead and some wad, and as being 200 yards wide (*op. cit.*, p. 265), and Pilkington in 1789 says of it, 'I have been informed that the Portaway Mine near Winster lately produced ore to the value of 4,000*l.* in seven weeks.'*

Will's Foundry Mine, on the Kevel† Vein, reached the toadstone at 50 fathoms, and got to limestone again at 70 fathoms. The Placket Vein runs under Winster Church, and has been worked for some 300 yards northwards. Farey speaks of it as a pipe with much lead, and with great caverns, one 180 yards high (*op. cit.*, p. 265). The Orchard Pipe runs through the centre of Winster. The Orchard Shaft was 50 fathoms in depth, and an attempt was made to drive southwards from it through the toadstone, which dips north. Farey says of this pipe that it was 150 yards wide, and had caverns in it (*op. cit.*, p. 265). On the east skirts of Winster are some less important veins, known as the Horsebuttock (green and brown ore in kevel), and the Bark Vein.

The Yatestoop Pipe ranges due north and south. The level runs at 100 fathoms depth under the north end of it. According to Farey (*op. cit.*, p. 270) it was a crooked vein, but yielded much ore, and was worked to 115 fathoms depth. The principal shaft is 400 yards east-south-east of Upper Town.

Some of the Winster veins have been followed south-eastwards beyond the outcrop of the toadstone, and worked in the limestone below. The Whitelow Vein has been already described. The Lick Penny Veins (or some scrins associated with them) were in 1887 yielding wad on the south side of the toadstone outcrop. A vein falling into a direct line with the Placket Vein has been worked at the top of the hill in the limestone, while on Bonsal Moor in beds below the toadstone are found a number of scrins falling into the same line. Here there are also veins ranging more nearly east and west. A thin bed of toadstone makes its appearance 500 yards east of Winster Moor Farm, but cannot be traced for many yards.

It is doubtful, however, whether any of these veins, excepting the Whitelow, can be said with certainty to run continuously through the toadstone. They are metalliferous joints and not faults, and though they abound in the limestones, disappear in a rock like toadstone, which does not lend itself to the formation of open joints.

Between Winster and Wensley are a vast number of old shallow workings, which seem to be chiefly on scrins ranging from

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* A View of the Present State of Derbyshire, p. 130.

† 'Kevel' or 'kebble' is a miner's name for spar.

N. 10°–45° W. The Davis Mine was one of the richest; it appears to have been on some scrins running about N.W. Boulders of siliceous and cherty rock occur here. The only vein now being worked is the Millclose, which has been very productive for many years.

Millclose Mine.

(From notes made in 1919.)

Owners.—The Millclose Mines, Ltd.

Site.—The main buildings are at Warrencar, ¾ m. W. by N. from Darley Bridge, near Matlock.

History.—The earliest operations of the Millclose Mine may be 200 years old, and probably started as a continuation, under the Yoredale Shales, of a group of surface workings on veins traversing the limestone outcrop south of Wensley village: these have ever since been followed progressively further north under the shale covering. Mander's Mining Glossary (1824) says that 'About the year 1743, the Quaker's Company, as it was then called, purchased the Mill Close Mine, in the Liberty of Wensley, . . . upon which they not only erected a fire engine, to draw water out of the mine, but also built coes . . . . ; they likewise wrought a sough, or water-gate (without having a vein), into Birchover Lordship, and diverted a brook, or water-course, down such, for the purpose of turning a water-wheel, which they had in this said mine.' The sough referred to appears to be the Yatestoop Sough.

The mine subsequently lay idle for about 100 years, but was reopened in 1859 by the late Mr. Wass. In 1861 ore began to be raised, and has continued uninterruptedly to the present day, except for two years (1875–77) when the mine was temporarily drowned out. After Mr. Wass's death in 1886, his trustees took over the mine, until 1919, when it was acquired by the Bradford Vale Mining Company, and sold to the present owners in 1922.

Geology.—The country rock is massive Carboniferous Limestone, covered by Yoredale Shales. Intercalated in the limestone, from 100 to 300 feet below the junctions with the shales, is a bed of 'toadstone.' These strata, on the whole, dip gently northwards, but are affected by minor undulations, of which the chief is the slight anticline E. of Stanton Leys, under Beehill Farm, and near the Fan Shaft (Plate II.).

The upper part of the limestone is somewhat cherty; there are some clay partings or 'wayboards,' and in the 'Black Beds,' about 36 feet below the shales, there is a seam of coal, an inch or two thick.

A certain amount of ore has been got from the base of the shales, but this is quite exceptional; the richest deposits have been got in the topmost layers of limestone, and repeated trials have shown that they do not extend below the toadstone.

The main vein runs N. or slightly E. of N. through the Old Millclose Mine up to Lees Shaft, 200 yards N. of Warrencar and then turns N. 30° W. for about half-a-mile, after which it gradually returns to a northerly direction. In the forefield, at the end of Hillcar Wood, it runs almost due N. and S. At Old Millclose there is a downthrow E. of 3 yards, but this is not observable elsewhere.

The vein has been in places as much as 20 feet wide, but as a rule it is much less. Though rich in galena in the higher levels, both ore and vein pinch out rapidly in depth : along the bottom, or 73-fathom level, the vein is but an inch or two across, the galena has disappeared altogether, and the only ores are rounded bosses of brown blende and iron pyrites.

The most striking feature of the mine is the heavily mineralized area found on either side of the main vein, but particularly well developed on the western side. This has given rise to excavations (known, in the old workings S. of Warrencar, as ' wides ') which ramify in every direction, and have occasionally been carried as far as 250 yards away from the main vein. The ore-bodies found here are quite evidently infillings of pre-existing solution cavities developed along the joints and bedding planes of the limestone. This is borne out by Mr. Cyril Parsons' full and most interesting description of the workings as he saw them in 1896,* and is confirmed by a recent inspection of the working places now visible in the forefield. The ore-bodies (found in ' caverns,' ' flats ' and ' fissures ') are connected with the veins by relatively insignificant ' feeders ' and subsidiary veins. Mr. Parsons says† that ' by following the feeders some of the largest caverns have been discovered. Only a fissure, as thick as writing paper, may exist : the miner driving in this, perhaps suddenly, breaks through into an enormously rich cavern that will provide work for years. Caverns are found unexpectedly along, or branching off, the main vein on or from its feeders. Their shape is irregular. They may measure as much as 60 feet in many directions, several caverns often connecting with each other.'

' Most of the best ore is obtained from caverns. The floor is generally covered with small and large angular blocks of the country rock, with large crystals of dogtooth spar, lumps and blocks of caulk and galena, and other associates . . . . In places, on the top of all this rubble, we find a black sediment of mud and hydrous iron oxide. . . . The roof is usually covered with incrustations of caulk, fluorspar, blende, masses of cubical galena (the cubes sometimes measure 2 inches across) and discoloured calcspars : the crystals of the dogtooth calcite will measure as much as 1 foot along their axes.'

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* ' The Deposit at the Millclose Lead-Mine, Darley Dale, Matlock,' by Cyril E. Parsons. *Trans. Fed. Inst. Mining Engineers*, vol. xii, (1896-7) p. 115, &c.

† *Loc. cit.*, p. 117.

' On surrounding ledges or cavities in the sides of these caverns, where no fallen rock has collected, we find the usual spars, galena, and associated minerals covered by mud as above-mentioned. The galena seldom forms such fine cubes on the floor as on the roof.'

' Flats form generally more or less horizontal deposits. They occur along the bedding-planes of the limestone. Near the fissure or feeder they are most productive, and thin out to nothing as they recede from it.'

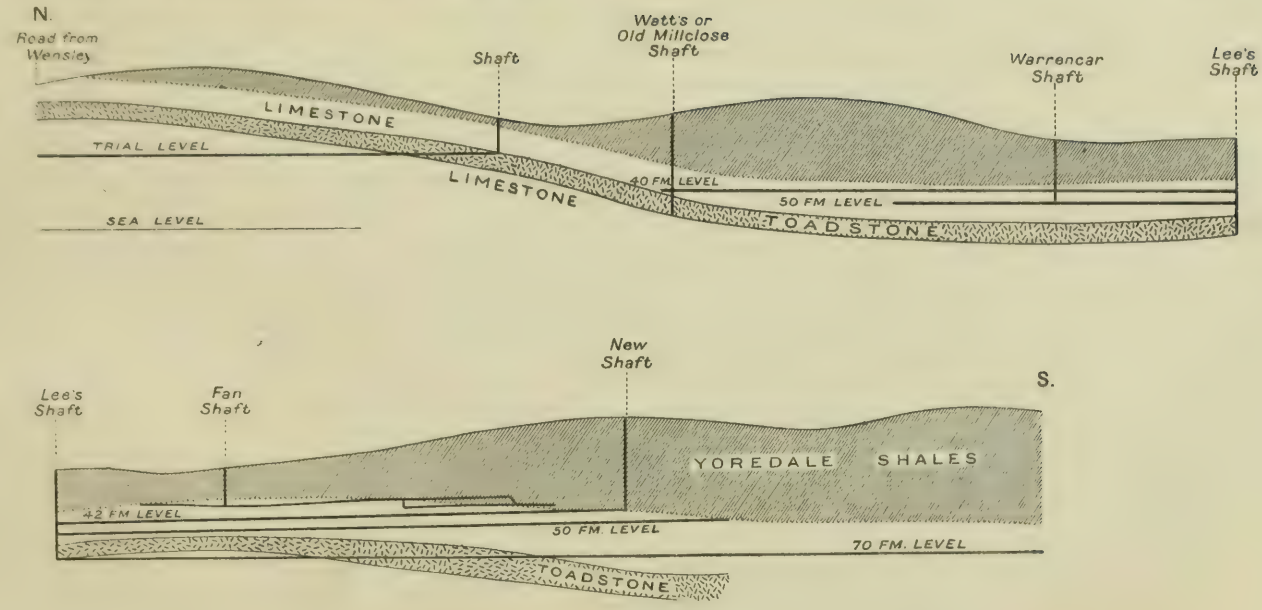
' Presumably here, as in other instances, water from the fissures has penetrated between the bedding-planes of the limestone, and eaten out an elongated, wedge-shaped cavity, the space being afterwards occupied with galena and other minerals.'

' The floor is generally irregular and undulating, rising or falling to or from the roof. After a time it rises to meet the roof and cuts out gradually all the ores. The roof generally remains more regular in accordance with the bedding-planes of the limestone above. Flats are common immediately beneath the ' wayboards ' and partings of clay which have evidently governed the circulations of the solvent waters in the limestone.'

In places, there is a soft ' sandy back ' to the ore-bodies, which are then easily removed : often indeed, they are dangerously loose. A good instance was observed when inspecting the forefield workings off the 73-fathom level in November 1919. The ore lay in a vertical fissure parallel to, and a few yards W. of, the main vein. This fissure, 5 or 6 feet wide, terminated abruptly below, and was filled with great masses of pure galena sometimes a foot across, intermingled with blocks of chert and soft decalcified limestone, with a little fluorspar. The walls of the fissure (which appeared to have originally been a joint plane enlarged by water) were not polished or slickensided, but were deeply pitted, and lined with a soft sand, resulting from a complete decalcification of the limestone ; casts of corals and other fossils, could still be seen in it. Apart from such cases, the limestone walls of the ore-bodies at Millclose are quite unaltered : they are not silicified or dolomitised, nor do they show any traces of metasomatic replacement, such as one sees in the ' flats ' of the Boltsburn Mine, in Weardale. The introduction of the ore evidently took place at a comparatively low temperature. Mr. Parsons* has observed that the seam of coal (which, as noted above, lies in the upper layers of the limestone) is not in the least altered where transgressed by the main seam.

As regards the sequence of crystallisation of the different minerals, a general rule is that blende was deposited first, next to the limestone, and was followed in turn by fluor, galena, earthy barytes (' caulk ') and finally calcite. This order is not a rigid one, of course. The blende may be absent altogether, and there may be two or more layers of galena ; iron pyrites may line a fissure or it may occur in the heart of the vein. Calcite, however, is

* *Loc. cit.*, p. 119.



SECTION OF THE MILLCLOSE MINE

Scale

0 ¼ ½ mile

6360 B 36/291 750 2 23

C & R.L^TD 800.

almost always the last mineral to form. The grey or amber-coloured 'dogtooths' of this spar, are a most striking feature in the hollow cavities which abound in the mine, and twinned crystals a foot long are by no means uncommon. Galena continues to a somewhat greater depth in the caverned areas than in the main vein, but in no case has it been got in payable quantity in or below the toadstone. Blende is perhaps most abundant along the 50-fathom level; it is certainly commoner there than in the higher workings, but in the caverned area it does not increase progressively in depth, galena* being the leading ore there, even in the bottom level, at 73 fathoms. Curiously enough, in the main vein close by, there is no galena at all, blende and iron pyrites being the only ores.

Copper pyrites and its green alteration products occur as mere traces. They show no sign of increasing in depth.

Mining.—The distribution of the shafts and levels along the main vein is shown in Plate II. Old Millclose, or Watts' Shaft, is now abandoned, Warrencar (sunk in 1873) is used for pumping, while winding is done from Lees Shaft, which was sunk in 1881 and deepened to 75 fathoms in 1901. The driving of the 73-fathom level opened up much new ground N. of New Shaft, and this is now the productive part of the mine. The first part of this level (*see* Plate II) runs in the toadstone and underlying limestone, which were as barren of ore as they were in the Old Mine, where the same strata were passed through in cutting a level southwards to the Wensley road.

Water is dealt with by three Cornish pumps, discharging into the Yatestoop Sough: it averages 1,800 gallons per minute, both winter and summer. In 1887, when the mine was much shallower, the quantity was not more than 1,000 gallons, but in driving the 73-fathom level heavy feeders were struck, and are still running.

Regarding the treatment of the ore, Mr. L. C. Stuckey, in an article written in 1917,† when he was manager of the mine, says 'The ore-dressing plant has been considerably altered and extended since 1883. . . . The speed of the jigs is high, being 180 strokes per minute on the coarse jig treating $\frac{5}{16}$-in. material. Experiments conducted on the slime material with a view to flotation treatment show that the oxidation of the fine particles of galena is so rapid that only fresh material can be satisfactorily treated. Wilfley tables were first installed in 1899, the older ones being replaced by Deisters in 1914.'

Transport.—An aerial ropeway, $\frac{3}{4}$ mile long, runs from the Warrencar Mine across the River Derwent to within a few hundred yards of Darleydale station (M.R.).

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* A white clay frequently covers the galena cubes, and analysis proves it to be a sulphate of lime and magnesia, with a little iron and sulphide.

† 'Lead Mining in Derbyshire with special reference to the Mill Close Mine.' By L. C. Stuckey, *Mining Magazine*, vol. xvi (1917), p. 201.

The Slack Mines, sunk on some veins running west of north, were worked in the bed below the toadstone, and are referred to by Farey (*op., cit.* p. 267) as having yielded much lead-ore.

At the Oxclose Mine, near Snitterton, a level is said to have been driven south into the 3rd limestone, in the hopes of finding a continuation of the veins which had been worked by the 'old men' in limestone above the toadstone, but the attempt failed. An old sough runs from the mine to the Derwent.

Matlock.

The mines of this neighbourhood have been long abandoned, and are inaccessible with the exception of those which are shown to visitors as objects of curiosity. The Dimple Mine, at Matlock Bank, yielded, according to Farey (*op. cit.*, p. 257), lead-ore associated with iron pyrites and fluorspar, and was the only mine in Derbyshire where a steam engine was in use in 1809. It was situated on the thin edge of the Yoredale Shale, and was the northernmost mine on the Seven Rakes. The Seven Rakes Mine was situated on the hill-side above the road from Matlock Bridge to Matlock Dale. It has already been alluded to (p. 46) for yielding ore in the toadstone after the limestone above and below this rock had been worked out, and the mine abandoned. Calamine and blende were as abundant in this vein as lead-ore. The vein crosses the river in Matlock Dale. The Great Rake crosses the river at the Paint Mill, near which the workings were carried to a depth of 20 fathoms below the river by the aid of pumps worked by a water-wheel. Warm water was tapped in this rake. Old Nestor's (or Nestus) Pipe, on Masson Hill, was reputedly one of the oldest mines in Derbyshire; it yielded much lead-ore, with calamine and blende (Farey, *op. cit.*, p. 263). The Side Rake, at Starkholmes, on the east side of the river, also produced ore in the toadstone, and yellow ochre was raised from High Tor Rake in the same neighbourhood.

The Cumberland or Rutland Mine at Matlock Bath produced lead-ore, calamine, some copper, and carbonate of iron (Farey *op. cit.*, p. 256). The pipe is said to range towards the Moletrap Mine, near Cromford Station. The Balls Eye Mine in the dale leading up to Bonsal has already been referred to as having yielded an argentiferous galena (p. 43). The pipe, where it comes out to day, was 100 yards above Bonsal Brook, but slopes down to a level with the brook. It was reached by a shaft 66 yards in depth, sunk through a loose limestone, about 12 to 14 yards thick, below which was some white and black clay (toadstone) 20 to 24 yards thick. The mass of lead-ore in one place was seven or eight fathoms high and twenty fathoms wide, and in a short time yielded 12,000*l.* profit. After three years, and when it had produced above 50,000*l.* worth of lead, the mine was drowned out.*

* The History of the Mineral Waters of Derbyshire, &c., by Thomas Short, M.D., 1734, p. 73. By 'lead-ore' is probably meant spar with lead ore

Wirksworth.

A great deal of work has been done in this neighbourhood, but, it is said, without a corresponding profit. Two old soughs are alluded to by Short (*op. cit.*, p. 93), one on the east side of the town about a mile long, and one on the west side, made about 1693, beginning on the south side of the town, and carried close up to the west side; both yielded warm water. The last mentioned is probably the Hannage Sough which drains into the Ecclesbourne at Millhouses, a few hundred yards south of Wirksworth Station, and runs thence to the Ratchwood Mine, between Wirksworth and Middleton; this sough was finished about 1740 (Farey, p. 329). These were followed by Cromford Sough, which, starting near Cromford Market Place, runs up to the Gang Mine and others near Wirksworth. Farey states that it brought down much warm water, and cost 30,000*l.* (*op. cit.*, p. 329).

The last driven was the Meerbrook Sough, which runs from the Derwent, three-quarters of a mile above Whatstandwell Bridge, to a shaft at Hag Wood, and thence by Bole Hill to Meerbrook Sough Mine, a distance of $2\frac{1}{4}$ miles. It was begun in 1773, was still driving in 1811, and is said to have cost more than 45,000*l.* Boats were used in it (Farey, p. 330). It has since been driven to a point about 100 yards south of Wirksworth church. The yield of lead in the Wapentake of Wirksworth in 1782 was 1,306 tons according to Pilkington (*op. cit.*, p. 126).

The greater part of the mining of late years has been in the hollow north-east of Wirksworth, and in the limestone to the north of this hollow. It will be seen by the map that the shale, by which the hollow is occupied, is thrown down by a fault running from Wirksworth to Middleton. This fault is known as the Gulf-fault, and has had an important influence on the veins, the greater number of which are parallel to it, with the direction N. 10°–40° W.; the principal of these are the Rantor (or Raventor), the Bage, and the Wall Close. The Gang Vein, however, towards the north, and the Yokecliff Rake, on the south of Wirksworth, run nearly east and west. Each is a powerful vein, throwing the beds down to the south.

The Wall Close Vein,* running nearly south-east, gathers a number of scrins from the south under Bole Hill, the principal being the Bage, Walker's Vein, and the Flint Vein. These were wrought in the Bage Mine, the shaft of which was 50 fathoms deep, or 17 fathoms short of the Meerbrook Sough. No toadstone has been seen in this mine. The galena was associated with caulk, and a little blende, very little fluorspar, and some white ore. Towards the north the Wall Close Vein crosses the Gang Vein and north of this point has lately yielded ochre. The Bage Mine in 1879 was employing 20 men and yielding 170 tons of lead a year.† There was a hot spring in this mine (Farey, p. 252).

* According to Mr. Alsop, of Wirksworth (1887).

† M. Léon Lecornu, *Ann. des Mines*, ser. 7, vol. xv, p. 5, 1879.

Dinah's Rake, about 300 yards west of the Bage Mine, was very rich in caulk. In the Rantor Vein also, which was worked for about 1,000 yards, Farey enumerates caulk, ochre, iron pyrites, blende, white ore, and much galena as having been got (*op. cit.*, p. 265). The Ratchwood Mine was worked on a very rich branch of ore in a scrin, parallel and close to the Gulf-fault; the shaft was 70 fathoms deep. Gell's Norcliff (or Twentylands) Mine was in a similar position further south; the shaft was 50 fathoms deep, the upper 14 fathoms being through the Yoredale Shale. The Meerbrook Sough Mine, in the bottom of the hollow, and by the side of the railway, was on the sough and on a small vein known as the Goodluck; the shaft was 50 fathoms deep, and reached the limestone through 17 fathoms of shale.

The Gulf is the name applied to the strip or wedge of shale let down by the Gulf-fault on the one side and by the Rantor Vein on the other. The Gulf-fault* runs at the foot of the limestone cliff in which the quarries are worked, and ranges to the Railway Station. The Rantor Vein, which forms the east side of the Gulf, appears to have been proved in a trial 150 yards north-east of the station. A shaft was sunk all in shale, and a cross-cut driven from it towards the south-east, in which direction the cover of shale would normally be thickening. In a few yards however the cross-cut entered limestone from which water boiled up with great rapidity, and the trial had to be abandoned.

The Gang Vein runs from the Shale Grit, north of Bole Hill, westward to near Middleton. It is a fault, but hades, and apparently shifts the strata, in different directions in different parts of its range. The Gang Mine† is at the east end of the vein, and was sunk through the Yoredale Shale to get to it, getting lead-ore in the shale. It produced ore also in the toadstone and tapped a warm spring in the 2nd limestone; with the ore were associated blende, iron pyrites, fluorspar in large cubes, and petroleum (Farey, p. 258). In 1811 in the forefield of the Gang Vein a superficial yard of the vein produced often, near the shale, upwards of 1,600 lbs. of ore, while in other and lower parts of the same vein the produce fell short of 300 lbs. (*ib.*, p. 269). At the Samuel Mine, south-west of Middleton, this vein is said to have proved very rich; the Cromford Sough runs at 120 fathoms depth in this mine. Thence the vein runs nearly south-west through the Bradhouse and Partridge Mines; at the former (where the toadstone was about 13 fathoms thick) a cross vein, running

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* The Gulf-fault appears to be the same as the Taylor's Vein described by Farey as having "the S.W. side highest by 162 yards; skirts dropped down, a Cavern." (*Op. cit.*, p. 265.)

† "In Gang Mine, whence a *slickenside* runs through the vein, the miner avails himself of a curious property attending such veins by drawing laces, stoops, or nicks, at about six inches apart and four inches deep, with the point of his pick, from top to bottom of his face of work, which he then leaves for several hours, and on his return finds all the vein-stuff so furrowed, spelled, or slappeted off, and laying on the sole ready got to his hands," (Farey, p. 367.) See also pp. 49 and 58 on slickenside.

S.E., is now (1919) being wrought for barytes, small amounts of galena being also got. An exploration of the Bradhouse shaft proved it to be 135 yards deep, and at the bottom the vein was only from 18 ins. to 3 ft. wide, mostly calc-spar and no galena, although it had been both rich and wide at the surface.

The Snake Mine, a few hundred yards to the north-west, is on a number of scrins running a little east of north. They and the toadstone of the Bradhouse Mine are seen in the Hoptonwood Quarry. The section of the strata at the Snake Mine is as follows :—*

	Ft.	In.
Toadstone		
Limestone	210	0
Clay, 1 foot Limestone, 3 feet } 'Bearing Clay'	5	0
Clay, 1 foot		
Limestone	36	0
'Tumbling Clay'	0	1
Limestone	60	0
'Ten-fathom Clay'		—
'Limestone'	22	9
Black beds	13	0
'Holystone,' a fine-grained limestone	119	0+

A fourth clay, the '20-fathom clay' (*i.e.*, 20 fathoms below the toadstone), is recognised by the miners. It is said to cut off the ore, while the 'bearing clay' is said to bring the ore in again, whence its name. Considerable importance is attached to these clays, and they are said to be recognisable over a large area round Cromford and Wirksworth, and, it is said, also, at Crich.

Two veins, running north-west, have been worked under Wirksworth, namely, the Bailey Croft, a little south of the Moot Hall, and the Blackman Croft, which runs under the west end of the church. In the churchyard there is more than one old shaft, and there was formerly a warm spring (Farey, p. 505).

The Yokecliff (or Oakcliff) Rake is a powerful fault throwing the Yoredale Shale down on its south side. As in the case of the Gulf-fault the limestone of the upthrow side makes a marked feature. The vein has been proved to be 10 yards wide under the dining-room of Gate House, and has been exhaustively worked thence westwards. It has yielded much galena and calamine, the ore being found in one place in the top of the vein, and scattered (under the soil) over a field on the south side of the vein, and known as California. The rake runs nearly due west, passing a little north of Carsington, and terminating 700 yards west of the church.

A small patch of limestone occurs on the south side of the Yokecliff Rake, and contains several veins. The Dream (or Stafford's Dream) Mine is on a vein running about east-north-

* From an old miner.

east; it was worked with great profit formerly to 60 fathoms depth, but not followed more than 140 yards west, where the shale comes on. The Sandhole Vein runs east and west through the Foxhole, (an open chasm from which calamine and ochre have been raised), and through a huge cavern discovered in the working of the mine. It takes its name from a hollow in the limestone, doubtless formed by the collapse of a cavern, and filled with sand (glacial), containing pebbles of quartzite, &c., and lumps of galena. The vein was unwatered by a level running to near Miller's Green Mill. Other veins, of which the Blobber is the principal, run west-north west.

Brassington.

This neighbourhood has been remarkable for its great deposits of white ore, associated with white sands and fireclays. There is a remarkable want of parallelism among such rakes as can be traced, but some of them have proved very rich. The Great Rake, running E. by S., and inclined steeply to the S., has been extensively wrought, and is now (1919) being worked for caulk, with galena as a subsidiary product. The drawing shaft ($\frac{3}{4}$ m. S.E. of Brassington Church) is 50 fathoms deep, and is sunk through the vein, which is from 4 to 11 ft. broad and full of caulk, accompanied by a little calcite. The galena is in scattered lumps, but forms less than $\frac{1}{2}$ per cent. of the raw output.

The old workings are known to extend to a depth of 70 fathoms, but are as yet unexplored below the 50-fathom level. The mine is quite dry, and there is much difficulty in getting enough water for the small dressing plant.

Caulk was abundant in the White Rake also, which runs W. 10° N.; but there was little of it in the Flaxpiece Rake, an easterly continuation trending W. 27° S. The Speedwell Mine was worked in a network of scrins, and yielded a great deal of ore in a small space. The Nickalum or Old Brassington Mine was on a pipe running a little W. of N.: there is a shaft here 10 fathoms deep, and from this, and also from the adjacent Beenest Shaft (22 fathoms) small amounts of caulk are now (1919) being obtained, but there is no galena.

The Wester Hollow Mines were dug in a deposit of white sand to a depth of 18 to 30 fathoms and yielded ' white ore ' (carbonate of lead).

The Chance Mine, situated immediately north of the railway at the top of the Hopton incline, was sunk to 57$\frac{1}{2}$ fathoms on a pipe. When reopened some years ago much calc-spar was found, with some galena and silicate of zinc, but further working was stopped by water. Another pipe, at the junction of three veins, was got in Shining Cloud Shaft, 60 fathoms deep and $\frac{1}{4}$ m. S.E. of Hopton cross-roads.

Golconda Mine.

(From notes made in 1919.)

Owners.—Hopton Mining Co.

Site.—1 mile 1 furlong N.E. of Brassington.

History.—This old mine, reported to have been very rich about the middle of the 18th century, has latterly been wrought intermittently, until 1915, when the Hopton Mining Coy. started active operations, which have continued since on an increasing scale.

Geology.—The mine is on a vein and pipe traversing a country rock composed of 'dunstone' (*i.e.*, dolomitic limestone) resting on ordinary limestone. The vein trends N.W., with several scrins crossing at right angles, and at the junction of the 'dunstone' and the limestone there is a well-defined 'flat' in which most of the galena is at present obtained. Vein, pipe and flat alike are filled with a soft caulk, mixed with fine red clay. Galena occurs in scattered strings and lumps, but is in very subordinate amount (about 1 per cent. of the whole). Cavities in the caulk are lined with silicate of zinc, and, more rarely calamine. There are occasional films of malachite (derived from specks of copper-pyrites) and calcite, in the form of dog-tooth spar, is fairly abundant.

The old workings are extraordinarily irregular, the removal of the ore having given rise to huge ramifying fissures. On the south side of the workings, extensions of the 70-fathom level broke into a group of narrow caverns, said to be 300 feet or more in height.

Mining, &c.—The main drawing shaft (Upper Golconda) is 770 yds. E. from Harboro' Farm, and is 70 fathoms deep (52 fathoms 'dunstone' on 18 fathoms of limestone): the pipe is intersected at about 60 fathoms. The old shaft (Lower Golconda) lies 417 yds. to the N.W. and is 45 fathoms deep, with the pipe at the bottom. The two shafts are connected by a level which is 60 fathoms deep at Upper Golconda; from this the present workings extend. The bottom, or 70-fathom level, is shorter, and has not been utilized of late years: it is driven westwards from the bottom of the main shaft for about 200 yards, when it enters the extensively caverned ground to which reference has been made above.

The mine is practically dry, and hardly yields enough water even for the dressing plant: such a condition is exceptional in Derbyshire, but it should be remembered that it lies on a high plateau, 500 or 600 feet above the bottom of the Griff Grange or Via Gellia valley, a mile to the N., so that the lowest workings, at 70 fathoms, would be above the general water-table of the district.

Galena is a subsidiary mineral at this mine, composing from ·5 to 1·5 per cent. of the material brought up, barytes being

the main product. The dressing plant is of normal design, and need only be described briefly. After passing through a jaw crusher and two sets of rolls the ore goes up a bucket elevator to four sizing trommels, 1, 3, 5 and 8 mm. From these, each size goes to the corresponding jigs : the 1st jig in each set removes the galena, the rest taking out barytes, while ' spar ' (calcite) is rejected. The residue refused by the trommels goes to a Wilfley vanner, and all the material from the galena compartment is finished on a slime dresser.

The silicate of zinc and calamine are not separated, the difficulty of treatment being too great. The calamine is in any case in very small quantity : some attempt has been made to get the silicate of zinc out by a hand-picking process, but it is not a payable subject at the present time. The traces of malachite and copper pyrites scattered through the ore-bodies are not of any economic account, nor is there any indication that they increase in depth.

Power for all operations at the mine is provided by a suction gas plant.

The mine is well situated for transport, being within a few hundred yards of the Cromford and High Peak railway (L. & N.W.R.).

Ecton (Staffordshire).

The Dale Mine was situated near the famous Ecton Copper Mine, but on the opposite side of the river Manifold. The ore, which was very plentiful, was obtained from a pipe, running a little west of north, and dipping down with a gradient of about 25° in this direction. It came to the surface about 16 fathoms south of the Footway Shaft (near a tributary stream of the Manifold). At No. 1 Engine Shaft it was 42 fathoms, at the New Shaft 104 fathoms deep. An adit-level entered the No. 1 Shaft at 32 fathoms depth. The galena was nearly solid in the pipe, and scarcely required dressing. It was valued at 120*l.* a fathom. The mine was closed about 1873.

The Hays Brook Mine was sunk through Yoredale Shale on to the top of the limestone, when it was drowned out. Lead-ore was worked in the shale.

Ashover.

This district, now being opened out again after many years of quiescence, was a large producer 150 years ago : in the years 1776–82, according to Pilkington,* Ashover raised 2,016 tons of lead ore annually. The numerous veins which traverse the limestone inlier have, in several cases, been followed well beneath the surrounding shales and grits. So long ago as 1803 the workings in the famous Gregory Vein had been carried a mile W. of the limestone outcrop, the New Engine Shaft, nearest to the forefield,

* *Op. cit.*, p. 126.

being 365 yards deep. The old Gregory, Overton and Milltown Mines had all stopped by 1856, and, apart from 'hillocking' for fluorspar, no further operations were undertaken till quite recently. The present Company, Ashover Mines, Ltd., was formed in 1910 and mining was resumed at Fallgate in 1916–17 after the completion of two new shafts, Spencer and No. 3 Milltown or Greyhound: in the meantime ore is raised from the latter, Spencer Shaft being used for pumping.

The limestone at Ashover is brought up on a sharp anticline, surrounded by Yoredale Shales and prominent escarpments of Millstone Grit, and it rests on a 'toadstone' of unknown thickness. The latter rock, in this particular district, is not a lava, but a bedded tuff, into which one of the old shafts penetrated for 70 yards without reaching the bottom. The ore-bodies, as elsewhere in Derbyshire, are restricted to the limestone measures, which are about 200 feet thick.

The veins run in three main directions, E., N.E., and N.W., and are notably rich in fluorspar. In the old days the Gregory, Overton, Milltown and Westedge Veins ranked first in importance.

The Gregory Vein runs nearly east and west. Starting at the river Amber it passes 100 yards north of Ravensnest (Overton Farm on the old one-inch map), and thence under the escarpment of Kinder Scout Grit to the New Engine Shaft, 400 yards north of Holestone (or Hallstone Farm). Here it takes a bend to W. 15° S., in which direction it had been followed for 400 yards from the shaft in 1803, when the mine was abandoned.* For nearly the whole of the course described it runs under the Yoredale Shale, and towards the west under Millstone Grit also. The shallower workings of the vein are unwatered by the Gregory or Cockwell Sough, which runs into the Amber a short distance above Woolley Bridge, nearly a mile below Cockwell. A branch was driven for 800 yards northwards along the east side of Fall Hill to drain the Milltown and Fall Hill Mines, and with the intention also of reaching the Townhead Vein; another branch driven northwards from the Gregory Vein unwaters the Overton Mines.

At Milltown the Gregory Vein has been worked to a depth of 28 yards below the sough (or about 55 yards below the surface) by the help of pumps worked by a water-wheel in Cockwell Cradle. The shaft north-west of Ravensnest was sunk to 120 yards depth, 60 yards in shale and 60 in limestone. The 'old men' had worked the vein in this direction down to the level of the sough, until the Yoredale Shale, dipping west, came down in the forefield. The New Engine Shaft was 365 yards deep, as shown on a plan† of the district made about the time when the mine was closed. It must have started in the Kinder Scout

* Pilkington, *in* 1789, refers to a shaft said to have passed through 240 yards of shale before reaching the limestone (*op. cit.*, p. 80), but Farey relates that the New or Winsey Shaft was sunk in 1790 *to* 1795 to 266 yards depth at a cost of 4,000*l.* (*op. cit.*, p. 326).

† In 1887 in the possession of Mr. Gregory and kindly lent by him.

Grit, which forms so prominent a feature all along the hill-side, and traversed the whole of the Yoredale Shale before reaching the limestone, but unfortunately no trustworthy section has been preserved.

The Gregory Vein is joined by the Overton Vein 530 yards east of the New Engine Shaft, and at the point of intersection proved extraordinarily productive. From the years 1758 to 1783, according to Pilkington (*op. cit.*, p. 128), the mine yielded lead to the value of 105,986*l.* 0*s.* 3½*d.*, with an average annual production of 1,511 tons. A little antimoniated lead-ore is said to have occurred here (Farey, p. 259), and fluorspar was abundant; brasil and bitumen were also not uncommon.

The Overton Vein runs E. 35° N., a few yards south of Overton Hall; a number of scrins, close and parallel to it, run under the hall and garden. The mines were drained by a branch of the Gregory Sough. Several small rakes start from both the north and south sides of Gregory Vein, in direction nearly parallel to the Overton Vein, but have not been followed many yards. Among them are Ravensnest (or Dumble Holes), New Close, Crash Purse, and the Hard Nab on the south, and Sanlant and Blaigh Grove on the north. There are also some parallel scrins 400 yards north-west of Overton Hall.

In Stars Wood and Fall Hill a set of 10 or 12 veins, having an average direction of N. 30°–35° W., has been worked. They may be followed by the old open workings in both places, and more especially in the quarries near Fall Gate, where they are open to daylight to a great depth. The Stars (or Tors, or Blackland) Rake, one of the principal, is rich in fluorspar of good quality; the Great Rake runs through the centre of the wood. Those in the quarry are also rich in yellow fluorspar, tinged with blue here and there, but are accompanied by strings of calcite. The slickenside is variable in direction, being both horizontal and vertical within a small space; the hade is generally to the east.

The Townhead Vein runs nearly east and west, and has been worked in a mine about 250 yards N.N.W. of Ashover Church. The shaft passed through 20 yards of shale, 60 of limestone, and touched the toadstone.

The Westedge Vein runs about E. 15° S., but curves as though to join the Townhead Vein southward. It follows the shale boundary very closely. The engine shaft reached the toadstone at about 60 yards. A hard yellow fluorspar (not suitable for chemical works) is common in the hillock, and Blue John and blende also occur. According to Farey, ore was got here in the toadstone, and petroleum in geodes in the shale (*op. cit.*, p. 269).

The Fallgate or Ashover Mines.

(From notes made in 1919.)

Owners.—Ashover Mines, Ltd.

Site.—¾ m. S.E. of Ashover.

Geology.—Fall Vein runs in a N.W. direction past Fall Hill, towards Ashover village, through massive bedded limestones inclined at 30° to the S.E., with shales above and 'toadstone' below. In sinking No. 3 (Milltown) Shaft, the limestone was found to flatten out rapidly in depth (*see* fig. 6). This unexpected flattening greatly increases the amount of ore-bearing ground accessible from the shaft.

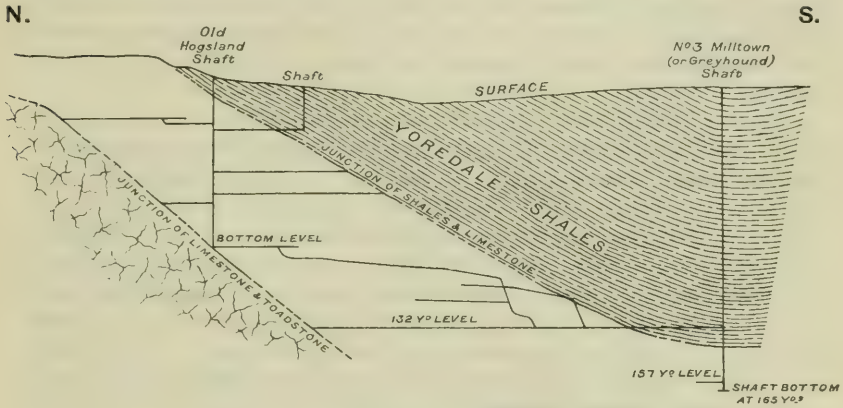

Fig. 6.—*Section at the Ashover Mines.*
Scale: 300 ft. to 1 inch.

Fall Vein is nearly vertical, having a very steep inclination to the S.W.; it may be 30 or even 40 feet broad, though much of this is silicified limestone with strings of fluorspar. There are three 'pay streaks,' the best showing 2 to 9 inches of galena in a 6 ft. vein of fluorspar. Calcite and a little iron pyrites are subsidiary minerals, while blende has been got close under the shale, but dies out in depth. Some rich pockets have been found on either side of the vein, and in the higher levels a good 'flat' was got off the old Hogsland Shaft about 48 yards down. On the N.W. side of this shaft 'Wilson's Pipe' yielded up to 40 per cent. of galena; the workings hereabouts broke into a cavern 60 yards deep.

Fletcher Vein, an offshoot from the N. side of Fall Vein, about 100 yards N. of Hogsland Shaft, runs E., and carries silicate of zinc, but not in marketable quantity.

Spencer's Rake lies on the S. side of Fallgate hamlet, running E. It was wrought in past times, and has recently been proved in depth by the new Spencer Shaft, where it was found 10 inches thick with a 3-inch rib of galena.

Mining, &c.—The earlier operations on the Fall Vein were conducted from the Hogsland Shaft, 300 yds. N.W. from the Greyhound cross-roads. This shaft started in shale but entered limestone about 15 yards down: it was 92 yards deep, 'toadstone' being touched at the bottom. Levels were driven off at intervals (*see* fig. 6) and all ore was extracted from the bottom of the shaft upwards. The new workings in depth were started by sinking

No. 3 Milltown Shaft on the S. side of the Greyhound cross-roads. This shaft is 165 yards deep, passing through 150 yards of Yoredale Shales before the limestone was reached. At 132 yards a long level, starting in shale, was continued through limestone (where it is said that there is 'good lead in the sole') until toadstone was encountered : rises were driven off above this and ore is now being extracted up to the 'old man's' workings along Hogsland Bottom Level (*see* fig. 6). In addition a deep level has been started at 157 yards, where the limestone flattens out, and there is at present no sign of impoverishment in depth.

Spencer Shaft, 170 yards W. by S. from No. 3, is 82 yards deep, all in shale, though limestone was touched at the bottom : it is at present used solely for pumping, the old Hogsland Sough not being utilised. The water was at one time as much as 14,000 gallons per hour (when the old workings were first tapped) but has now for some time averaged from 6,000 to 8,000 gallons.

The dressing plant is identical with that at Golconda Mine (*see* p. 82). Of the raw material raised, galena forms about 10 per cent., most of the remainder being fluorspar. The galena has a very low silver content, not worth extracting, and is said to give a soft lead on refining.

Transport is by Foden tractor to Stretton Station (M.R.) 2 miles away.

Crich.

In this mining field, important from very early times,* some very rich pipes have been wrought. Although no longer active, the district is of much interest, for the best ore was got well beneath the toadstone, and the workings are among the deepest in the country, the Old End mine having gone down nearly 1,000 feet before the ore gave out.

Messrs. Wedd and Drabble† state that fluorspar prevailed (often composing the whole gangue) in the 300 feet of limestone above the toadstone, while below that rock the gangue was calcite.

The richest deposits of galena have been about 70 feet below the toadstone : the veins above this work were loose and 'pipy,' while below it they were concentrated and hard.

The lodes are confined to the northern half of the limestone-mass. They range in two directions, roughly N.E. and N.W. The chief veins trending N.W. are, from north to south, the Hard Rake, the Church Rake, and two parallel rakes south of the last named. The N.E. group are the Glory Vein with its branch the Plaistowfield, and Pearson's Venture on the western

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* A lead mine at 'Crice' is referred to in Domesday Book. In 1782 the mines in the liberty of Crich yielded 200 tons of lead. Pilkington, *op. cit.*, p. 126.

† *Trans. Instit. Mining Engineers*, vol. xxxv, 1908, p. 519.

margin of the limestone outcrop. Near the junction of the last-named vein with the Hard Rake are rich pipes, the most important one known as the Bacchus Pipe. The mines are unwatered by the Fritchley and the Ridgway Levels. The former runs from the Old End Mine to a brook near Fritchley, the entrance bearing date 1753. The Ridgway Level, which was being driven in 1811 (Farey, *op. cit.*, p. 331), drains the Wakebridge and Cliff Side Mines, and empties itself into the Derwent 600 yards above Whatstandwell Bridge. The water from the Cliff Side Mine is warm.

Some remarkable variations in thickness of the toadstone at Crich Cliff have been observed in the course of the mining, and have been recorded by Mr. J. Alsop.* A bed of clay, 1 foot thick, becomes within a short distance 14 feet thick, and contains large nodules of compact toadstone, while the thick bed of toadstone, actually sank through at one shaft, diminishes to a thin bed at the other mine; the beds were traced continuously through from mine to mine. It is stated also that the three clays, mentioned in the section at the Snake Mine, are recognisable at Crich.

The Wakebridge Engine Shaft† was 110 fathoms deep, or 40 fathoms below the Ridgway Level; it was originally sunk on a pipe-vein running northwards. The Long Gate (a continuation of the Ridgway Level) was driven north from the shaft along the 'leading' of the pipe for nearly 400 yards, when it intersected the Glory Vein, which runs W. 27° N. Turning eastwards along this vein it passed through the toadstone in a length of about 40 yards, which, with the dip of 45°, indicates a thickness of about 35 yards for this rock.

The following details respecting the lead-mines on Crich Hill were kindly furnished by the late Mr. E. M. Wass, of the Lea Lead Works, Matlock.‡

"At the Glory Mine, north of Crich Stand, a much wrought, and in past years very remunerative, mine, the toadstone was discovered 30 fathoms from the surface, and found to be $9\frac{1}{2}$ fathoms thick. The lowest workings at this mine were 135 fathoms from day; the veins, however, diminished so materially in strength and productiveness the lower they were followed as to discourage trial requiring pumping machinery. A few men only are now making search above water mark but with little success.

"The Old End Mine, on the eastern slope of the hill and north of Crich Stand, has been explored to a greater depth than any of its neighbours. The toadstone there was arrived at in 50 fathoms, the deepest workings went down about 152 fathoms. The plant at this mine is now on sale, pumping operations having

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* *Brit. Assoc. Report* for 1844, (*Trans. Sections*), p. 51, and *Edin. New Phil. Journ.*, vol. xxxviii, p. 179.

† Information given in 1887 by Mr. William Spencer.

‡ Letter, dated March 23, 1868.

been suspended in consequence of the unfavourable appearance and gradually diminishing yield of the veins the lower they were cut." The Fritchley Level entered the shaft at about 70 fathoms depth. On the north side of the Glory Vein runs the Plaistowfield Vein, ranging about N. 37° W.

"In the Pearsons Venture, situated on the west side of the hill, the toadstone was reached at a depth of about 80 fathoms, its thickness was 11 fathoms. This has been a most productive mine, both above and below the toadstone, but at a depth of 115 fathoms the vein became contracted and poor, and this ground being heavily watered was abandoned.

"The Bacchus pipe is also on the west side of the hill; there the toadstone was found after sinking 75 fathoms, and its thickness ascertained to be 20 fathoms."

In these mines the veins became poorer the lower they were followed, and Mr. Wass in the letter quoted writes, "My own experience certainly confirms what has been frequently advanced, namely, that, *as a rule* our veins are stronger and more productive in the upper than in the lower parts of the limestone."

The pipes in which these mines were worked are probably connected with the narrow veins of fluorspar, caulk, and galena, which may be seen in the quarry above. Some Blue John occurs in Crich Hill, but not in sufficient bulk to be marketable.

The two mines last mentioned were drained by the Cliff Side branch of the Ridgway Level ; the branch enters the level about 100 yards west of the Rolley Shaft, near Wakebridge, and brings down a water described as having the ' warmth of new milk.'

CHAPTER V.

NOTES ON LEAD AND ZINC MINING IN THE ISLE OF MAN.

Since the publication of the Survey Memoir on 'Economic Geology of the Isle of Man' (1903), in which particulars and conditions of the mineral industries of the Island up to the close of the last century were fully described, the history of its mining has been one of persistent decline, so that in 1919, when the Island was revisited, the production of lead and zinc was entirely in abeyance, owing to a prolonged strike at the only remaining operative mine, that of Great Laxey. In the year 1900, ores of lead or zinc, or both, were being raised from the mines at Foxdale, Laxey and Snaefell, but the Snaefell mine was closed in 1908, and underground working ceased at Foxdale in 1911, with very little prospect of resumption at either place. Mining was however continued at Laxey until closed by the above-mentioned strike early in 1919, and there has been also since the former memoir was written a little unproductive exploratory work at other sites, to which some reference will be made in the following notes. The output of lead and zinc from the Manx Mines during the present century has been as follows, this Table being supplementary to the earlier statistics given in the previous memoir.

Isle of Man Ore Outputs since 1900.

Year.	Lead-ore (tons).				Zinc-ore (tons).		
	Laxey.	Foxdale.	Snaefell.	Total.	Laxey.	Snaefell.	Total.
1900	95	3,610	138	3,843	1,216	908	2,124
1901	112	3,550	112	3,774	862	1,035	1,897
1902	108	3,930	154	4,192	963	961	1,924
1903	98	3,400	106	3,604	1,180	517	1,697
1904	129	3,050	95	3,274	1,538	345	1,883
1905	176	2,850	44	3,070	1,685	275	1,960
1906	119	2,300	92	2,511	2,017	406	2,423
1907	213	1,800	90	2,103	2,388	471	2,859
1908	218	2,408	73	2,699	2,103	309	2,412
1909	280	2,240	—	2,520	1,876	—	1,876
1910	294	1,720	—	2,014	2,025	—	2,025
1911	300	630	—	930	1,860	—	1,860
1912	300	—	—	300	2,050	—	2,050
1913	300	—	—	300	953	—	953
1914	323	—	—	323	1,621	—	1,621
1915	229	—	—	229	1,401	—	1,401
1916	208	—	—	208	865	—	865
1917	165	—	—	165	897	—	897
1918	208	—	—	208	957	—	957
1919	129	—	—	129	787	—	787

Particulars of Workings since 1900.

Foxdale.—In the description of the Foxdale Mines contained in the previous memoir, it is stated that the three shafts then in operation were Bawden's, with a bottom level at 260 fms.; Beckwith's, with a level at 305 fms. and being in process of deepening to 320 fms.; and Pott's, with the bottom at 200 fms. By subsequent development, Bawden's was carried down to allow a 290-fm. level, and Beckwith's to a 335-fm. level, and it was in these two shafts only that the later working of the mine was prosecuted. Both shafts were vertical, and the lode was reached in the deeper levels by cross-cuts, that from Beckwith's being 17 fms. long at the 335-fm. level, and that from Bawden's being 60 fms. long at the 290-fm. level. The lode continued of average thickness to the bottom, but its productiveness varied, and the lowest levels were driven westward in poor ground. An ore-shoot was struck in the 335-fm. level at 30 to 40 fms. west of Beckwith's shaft, carrying 35 cwt. of lead to the fathom, and an auxiliary shaft was sunk from the level on the shoot to 350 fms., with drivings out east and west at this depth, but soon lost the ore, which still continued, however, in the sole of the auxiliary shaft. The heavy pumping and mining costs involved in raising this ore proved prohibitive and led to the closing of the mine, all the work at higher levels having also ceased to be remunerative.

Great Laxey Mines.—Since our previous description of these mines, Dumbell's Shaft has been deepened, and a bottom level (formerly at 266 fms.) driven at 302 fms. to connect with the old 295-fm. level from Welsh's Shaft. This level was carried N. from Dumbell's for 336 fms., under the main ore-shoot, with poor results, finding only patchy blende and galena, yielding about 1 ton lead, and 2 tons blende per fathom, with a little stoping ground at the N. end. The continued deterioration of the ore-body in depth was exhibited in this working. The principal later development of the mines has therefore consisted in driving and stoping at higher levels, and in re-opening some of the south coppery ground, rendered feasible by the rise in the price of metals.

The exploratory northward level at 225 fms. in Dumbell's Shaft, mentioned in our previous account, was driven out to 850 fms. from the shaft, but without discovering any workable deposits of ore. Toward the end of 1901, this driving tapped a heavy feeder of water, apparently contained in a 'slide' (fault), which stopped all further progress and temporarily flooded the mine up to the 110-fm. level. An adit-level pushed northward under the hill for 736 fms. from Dumbell's Shaft, has also failed to find paying ore.

The mines were closed in the summer and autumn of 1919.

Snaefell Mine.—This mine continued in operation until July, 1908, when a fall of rock occurred in the shaft at about 25 fms. below the surface, wrecking and practically blocking it from about 40 fms. downward. The ore was not exhausted, but the mine had been long unprofitable, so that there was no inducement to re-open it after the accident.

In the account given in the previous memoir, it is mentioned that the deepest level was at 171 fms. The later workings were mainly in this level, in which, at 760 yds. north from Engine Shaft, a shoot of ore was struck which yielded from 15 cwt. to 50 cwt. blende per fm., with a little lead. An auxiliary shaft was sunk from the level on this shoot and was sunk to 198 fms., with ore still in the sole. From the auxiliary shaft a level was driven at 196 fms. northward for 21 fms., but had no ore in the last 18 fms., and the ore-shoot was also proved to give out southward. There was some good stoping ground in the shoot between the 196 and the higher level, and in 1906 the mine was yielding about 25 tons blende and 6 tons lead per month, and just paying its way, but with dubious prospects. There was estimated to be about 150 tons of broken ore in the mine when the accident occurred that closed it.

Miscellaneous Trials, &c.—Some further exploratory work has been done in the outskirts of Foxdale since the previous memoir was written, but without permanent result. The Bell Hole Mining Co. re-opened some of the old workings on the Foxdale cross-courses known as Magee's Vein and Flappy Vein, these workings being unwatered by an adit driven in from the adjacent valley (*see* Memoir pp. 506, 510); a few tons of galena were obtained from the Flappy Vein. Re-examination of the old Beckwith Mine and Cross Mine in Glen Rushen has also led to no new development.

In the north of the Island, a patch of galena, yielding about 2 tons of ore, was found in 1903–1904 during quarrying operations at Kerroo Mooar, but soon terminated. Previous workings in this locality are described in the former memoir, p. 546.

APPENDIX I.

List of the Mines and Veins showing the Geological Map on which they appear.

Name.	Pages on which reference is made in the Memoir.	One-inch Maps.		Six-inch Geological maps
		Old Series Geological.	New Series Ordnance.	
WEARDALE.				
Boltsburn Mine	8–13	102 N.E.	25	Durham 16, 23.
„ Vein	8–13	102 N.E.	25	„ 16, 23.
Bracken Sike Vein	5	102 N.E.	25	„ 22.
Burtree Pasture Mine	5, 6	102 N.E.	25	„ 22.
„ Vein	5	102 N.E.	25	„ 22.
Cowhorse (or Cowhaust) Vein.	4–5	102 N.E.	25	„ 22.
Greenlaws Mines	7–8	102 N.E.	25	„ 23.
„ East Vein	7	102 N.E.	25	„ 23.
„ West Vein	7	102 N.E.	25	„ 23.
Grove Rake Vein	8	102 N.E.	25	„ 16.
Harthope Old Mine	7	102 N.E.	25	„ 23.
Killhope Mines	4–5	102 N.E.	25	„ 15.
Killhopehead Vein	4	102 N.E.	25	„ 15, 22.
Lodgefield Vein	6	102 N.E.	25	„ 23.
Middle Groove Vein	4	102 N.E.	25	„ 15.
Old Fall Vein	6	102 N.E.	25	„ 23.
Reahope Vein	14	102 N.E.	25	„ 23.
Red Vein	13, 14	102 N.E.	25	„ 23.
Sedling Mine	6	102 N.E.	25	„ 22, 23.
Slitt Mine	6	102 N.E.	25	„ 23.
„ Vein	6	102 N.E.	25	„ 23.
Stanhopeburn Mine	13–14	102 N.E. 103 N.W.	25 26	„ 23, 24.
Stotsfieldburn Mine	13	102 N.E.	25	„ 23.
Swan's Vein	14	102 N.E.	25	„ 23.
Wolfcleugh Old Vein	8	102 N.E.	25	„ 16, 23.
TEESDALE.				
Annie's Vein	23	102 N.E.	25	Durham.
Ashgill and Langty Mines.	22–23	102 N.E.	25	„ 30.
"B" to "H" Veins (Skears).	20	102 S.E.	31	[Durham 39 N.E.]
Black Vein	21	102 N.E.	25	[„ 31 S.W.]
„ Lead Vein	22–23	102 N.E.	25	„ 30.
Coldberry Mine	19	102 N.E.	25	[„ 39 N.E.]
Cowgreen Mines	24	102 N.E.	25	„ 30.
Dirt Pit Mine	15, 21	102 N.E.	25	[„ 39 N.W.]
Dubbysike Mine	24	102 N.E.	25	„ 30.

Name.	Pages on which reference is made in the Memoir.	One-inch Maps.		Six-inch Geological maps.
		Old Series Geological.	New Series Ordnance.	
TEESDALE—*continued.*				
East Rake Vein	16	102 N.E.	25	Durham 32,[40 N.W.]
		103 N.W.	26	
Flake Bridge Vein	16	103 N.W.	26	,, 32,[40 N.W.]
Flushiemere Mine	21	102 N.E.	25	[,, 31 S.W.]
Graham's Vein	21	102 S.E.	31	[,, 39 N.E.]
Grasshill North Vein	22	102 N.E.	25	,, 30.
Greenhurth Mine	23, 24	102 N.E.	25	,, 30.
Hardberry Hill Vein	19, 20	102 S.E.	31	[,, 39 N.E.]
High Cross Vein	22	102 N.E.	25	,, 30.
Highfield Mines	22	102 N.E.	25	,, 30.
Horne's Vein	19	102 S.E.	31	[,, 39 N.E.]
Hunt's Coldberry Vein	19, 20	102 S.E.	31	[,, 39 N.E.]
Isabella Mine	24	102 N.E.	25	,, 30.
Jane Ann Mine	24	102 N.E.	25	,, 30.
Ladyrake Mine	23	102 N.E.	25	,, 30.
Lodge Sike Vein	18, 19, 20	102 N.E.	25	[,, 39 N.W., N.E.]
		102 S.E.	31	
,, Sun Vein	18	102 N.E.	25	[,, 39 N.E.]
Low Vein	21	102 N.E.	25	[,, 31 S.W.]
,, Cross Vein	22	102 N.E.	25	,, 30.
Maizebeck Mines	25	102 S.E.	31	[Yorkshire 1 S.W.]
Manor Gill Vein	16	102 N.E.	25	[Durham 39 N.E.]
,, North Vein	16, 18, 19	102 N.E.	25	[,, 39 N.E., 40 N.W.]
Marlbeck Mine	20	102 S.E.	31	[,, 39 N.E.]
Martha Mine	24	102 N.E.	25	,, 30.
Middle Streak Vein	22	102 N.E.	25	,, 30.
New Wiregill Vein	17	102 N.E.	25	,, 32.
North Langty Head Vein (or Ashgill Head).	22	102 N.E.	25	,, 30.
North Vein	22	102 N.E.	25	,, 30.
North (or Beadle's) Vein.	19	102 S.E.	31	[,, 39 N.E.]
Old Wiregill Vein	17	102 N.E.	25	,, 32.
Pike Law Mine	21	102 N.E.	25	[,, 31 S.W.]
,, Vein	21	102 N.E.	25	[,, 31 S.W.]
Pikestone Brow Mine	19	102 N.E.	25	[,, 39 N.E.]
Pott's Vein	18	103 N.W.	26	,, 32.
Raine's Vein	20	102 S.E.	31	[,, 39 N.E.]
Ravelin Vein	20	102 S.E.	31	[,, 39 N.E.]
Reddycomb Mine	25	102 N.E.	25	,, 30.
Richardson's Vein	19	102 S.E.	31	[,, 39 N.E.]
,, South Vein	19	102 S.E.	31	[,, 39 N.E.]
Robinson's Vein	19	102 S.E.	31	[,, 39 N.E.]
Shamberry Vein	16	103 N.W.	26	,, 32.
,, North Vein	16	103 N.W.	26	,, 32.
,, South Vein	16	103 N.W.	26	,, 32.
Silverband Mines	25	102 S.E.	31	[Yorkshire 1 S.E.]
Skears Mine	20	102 S.E.	31	[Durham 39 N.E.]
,, Old Vein	21	102 S.E.	31	[,, 39 N.E.]

Name.	Pages on which reference is made in the Memoir.	One-inch Maps. Old Series Geological.	One-inch Maps. New Series Ordnance.	Six-inch Geological maps.
TEESDALE—*continued.*				
South Cross Vein	24	102 N.E.	25	
„ End Vein	24	102 N.E.	25	
„ Langty Vein	23			
Sun (or Lowe's) Vein	19	102 S.E.	31	Durham 39 N.E.]
Teesdale Cross Vein	24	102 N.E.	25	„ 30.
Vein "C" (Flushiemere.)	21	102 N.E.	25	[„ 31 S.W.]
Walton's Vein	21	102 S.E.	31	[„ 39 N.E.]
Willyhole Mines	15, 24	102 N.E.	25	„ 30.
SWALEDALE.				
Alderson's Lode	28	97 N.W.	40	[Yorkshire 36 S.E.]
Arn Gill Mines	27	97 N.W.	40	[„ 36 S.W.]
Barbara Lode	28	97 N.W.	40	[„ 36 S.E.]
Black Vein	29	97 N.E.	41	[„ 37 N.W.]
Blackethwaite Vein	27	97 N.W.	40	[„ 36 N.E.]
Blind Gill Vein	27	97 N.W.	40	[„ 36 N.E., S.E.]
Brandy Bottle Lode	28	97 N.W.	40	[„ 36 S.E.]
Bunton Hush	27	97 N.W.	40	[„ 36 S.E.]
Cherry's Vein	28	97 N.W.	40	
Cocker Rake	29			
„ Vein	27			
Cockrake Vein	26	97 N.W.	40	[„ 36 S.W.]
Copperthwaite Vein	29	97 N.E.	41	[„ 37 S.E.]
„ North Vein	29	97 N.E.	41	[„ 37 S.E.]
Dam Rigg Mine	29	97 N.W. / 97 N.E.	40 / 41	[„ 36 N.E.] / [„ 37 N.W.]
„ Vein	29	97 N.W. / 97 N.E.	40 / 41	[„ 36 N.E.] / [„ 37 N.W.]
Fell End Mine	29	97 N.E.	41	[„ 37 N.E.]
Freeman's Lode	28, 29			
Friarfold Hush	27	97 N.W.	40	[„ 36 S.E.]
„ Rake	28	97 N.W.	40	[„ 36 S.E.]
Gorton Hush	27	97 N.W.	40	[„ 36 S.E.]
Grinton Howe Mine	30	97 N.E.	41	[„ 52 N.E.]
Grovebeck Mine	30	97 N.E.	41	[„ 52 N.E.]
How Vein	30	97 N.E.	41	[„ 52 N.E., S.E.]
Lownathwaite Mines	27, 28	97 N.W.	40	[„ 36 S.E.]
'Modesty Flat'	30	97 N.W.	40	[„ 51 N.W.]
Moorhouse Lode	28	97 N.W.	40	[„ 36 S.E.]
North Rake	28, 29			
„ Vein	29			
Old Gang Mines	26, 27, 28	97 N.W.	40	[„ 36 S.E.]
Old Rake	27, 28	97 N.W.	40	[„ 36 S.E.]
Providence Mine	30	97 N.W.	40	[„ 51 N.W.]
Racca Vein	29	97 N.E.	41	[„ 37 S.E.]

Name.	Pages on which reference is made in the Memoir.	One-inch Maps.		Six-inch Geological maps.
		Old Series Geological.	New Series Ordnance.	
SWALEDALE—*continued.*				
Reformer's Vein	28	97 N.W.	40	[Yorkshire 36 S.E.]
Silver Hill Lode	28	97 N.W.	40	[,, 36 S.E.]
Spout Gill Mine	30	97 N.W.	40	[,, 51 N.E.]
Stony Hill Mines	26			
Sun (or South Mid) Vein	29	97 N.W.	40	[,, 36 N.E.
		97 N.E.	41	[,, 37 N.W.]
Surrender Mine	28			
Swinnergill Mines	26, 27	97 N.W.	40	[,, 36 S.W.]
Tanner Rake	29	97 N.E.	41	[,, 37 N.W.]
Watersikes Vein	28	97 N.W.	40	[,, 36 S.E.]
,, Sun Vein	28	97 N.W.	40	[,, 36 S.E.]
Windegg Vein	29	97 N.E.	41	[,, 37 N.W., N.E.]
PATELEY BRIDGE AREA.				
Blackhill Vein	33			Yorkshire.
Carnet Mine	31	92 N.E.	61	[,, 135 N.W.]
,, Vein	31	92 N.E.	61	[,, 135 N.W.]
Craven Cross Vein	33			
Fielding Vein	33			
"Flatting Beds" (Nursery Knott).	33			
Folly Vein	31			
Foxholes Vein	33			
Greenhow (Greenhaugh) Mines.	32–34	92 N.E.	61	[,, 135 N.W., S.W.]
Haiding Vein	31			
Harker Vein	33			
Hazle Vein	31			
Jamie Vein	33			
Lolly Mine	30	97 S.E.	51	[,, 117 N.W.]
Lonsdale Vein	33			
Merryfield Mines	31	92 N.E.	61	[,, 135 N.W.]
New South Vein	31			
North Rake	33			
Prosperous Mine	31	92 N.E.	61	[,, 135 N.W.]
Providence Mine	31	92 N.E.	61	[,, 135 N.W.]
South Vein	31			
Stony Grove Mine	31	92 N.E.	61	[,, 135 N.W.]
,, Vein	31	92 N.E.	61	[,, 135 N.W.]
Waters Vein	33			
GRASSINGTON.				
Appletreewick Pastures Mine	37	92 N.E.	61	[Yorkshire 134 S.E.]
Beever Vein	36	92 N.E.	61	[,, 134 N.W., N.E.]

Name.	Pages on which reference is made in the Memoir.	One-inch Maps.		Six-inch Geological maps.
		Old Series Geological.	New Series Ordnance.	
GRASSINGTON—*continued.*				
Burnt Ling Lode	35	92 N.E.	61	Yorkshire 116.
Bycliffe Mines	35, 36	92 N.E.	61	,, 116.
,, Vein	35	92 N.E.	61	,, 116, [135 N.W.]
Cobbler's Vein (Elbolton).	36	92 N.E.	61	[,, 134 S.W.]
Cockburn's Vein	36	92 N.E.	61	[,, 134 N.W., N.E.]
Cross-cut Vein	36	92 N.E.	61	[,, 134 N.W.]
Derby Vein	37	92 N.E.	61	[,, 134 S.E.]
Devonshire Vein	36	92 N.E.	61	[,, 134 N.W.]
Green Bycliffe Mine	35	92 N.E.	61	,, 116.
Grey Vein (Yarnbury)	36	92 N.E.	61	[,, 134 N.W.]
Groove Gill Mine	35	92 N.E.	61	,, 116.
Hooksbank Vein	37	97 S.E.	51	,, 116.
How Gill Mine	35	92 N.E.	61	,, 116.
Legran's (Legrim's or Palfrey Vein).	35	92 N.E.	61	,, 116.
Middle Vein	35	92 N.E.	61	,, 116.
,, (Elbolton)	36	92 N.E.	61	[,, 134 S.W.]
Moorhead Vein	38			
Napoleon Vein	37	92 N.E.	61	[,, 134 S.E.]
New Rake Vein	36	92 N.E.	61	[,, 134 N.W.]
North Vein (Appletreewick).	37	92 N.E.	61	[,, 134 S.E.]
North Vein (N.E. of Grassington).	37	92 N.E.	61	,, 116.
Old Providence Vein	37	97 S.E.	51	,, 116.
Peru Mine	35	92 N.E.	61	,, 116.
Richard's Vein	35	92 N.E.	61	,, 116.
Ringleton's Lode	35	92 N.E.	61	,, 116.
Silver Rake	37	92 N.E.	61	,, 116.
Simpson's Vein	36	92 N.E.	61	[,, 134 N.W.]
Slanter Lode	35	92 N.E.	61	,, 116.
Smith'sVein(Elbolton)	36	92 N.E.	61	[,, 134 S.W.]
Star Vein	36	92 N.E.	61	[,, 134 N.E.]
Stony Nook Vein	37	92 N.E.	61	[,, 134 S.E.]
Summer's Vein	37	92 N.E.	61	[,, 134 S.E.]
Trow Scar Vein	35	92 N.E.	61	,, 116.
Twenty Meres Vein	37, 38	92 N.E.	61	,, 116.
Yarnbury Mines	36	92 N.E.	61	[,, 13 N.W.]
AREA SOUTH OF CROSS FELL.				
Barrow Vein	39	102 S.E.	31	[Westmorland 5 S.E.]
Cabbish Mines	40	102 S.E.	31	[,, 17 S.W.]
Cavern Vein	40	102 S.E.	31	[,, 17 N.W.]
Dobson Vein	39	102 S.E.	31	[,, 5 S.E.]
Dufton Fell Mines	38, 39	102 S.E.	31	[,, 5 S.E.]
Hunter's Hush Vein	39			
Little White Vein	40			

Name.	Pages on which reference is made in the Memoir.	One-inch Maps.		Six-inch Geological maps.
		Old Series Geological.	New Series Ordnance.	
Area South of Cross Fell—*continued.*				
Lunehead Mines (New Vein, &c.).	39	102 S.E.	31	Yorkshire 3 S.E.
Rupert's Vein - -	38			
Scordale(Hilton)Mines	39	102 S.E.	31	[Westmorland 10S.W.]
Silverband Mines -	38, 39	102 N.E.	25	[„ 5 N.E.]
Sun Dobson Vein -	39	102 S.E.	31	[„ 5 S.E.]
Vein I. - - -	40			
Derbyshire.				
Castleton.				
Coalpit-hole Vein -	50, 51–52	81 N.E.	99	
Dirtlow Mine - -	50, 51	81 N.E.	99	
„ Rake - -	49, 50, 51, 52.	81 N.E.	99	
Faucet (or Foreside) Vein.	49, 50	81 N.E.	99	
Gautrie's Rake -	52	81 N.E.	99	
Hazard Mine - -	50, 51	81 N.E.	99	
Hollandtwine Mine -	50	81 N.E.	99	
Kitle End Vein -	50	81 N.E.	99	
Long Cliff Vein -	49, 50	81 N.E.	99	
„ Rake - -	51	81 N.E.	99	
Lower Slitherstone Mine.	51	81 N.E.	99	
Moss Rake - -	51			
New Rake - -	49, 50	81 N.E.	99	
Nunlowend Mine -	51	81 N.E.	99	
Odin Mine - -	48, 49	81 N.E.	99	
Old Moor Mine -	50, 51	81 N.E.	99	
Oxlow Rake - -	50, 52	81 N.E.	99	
Pindale (or Ashton's) Mine.	50	81 N.E.	99	
Portaway Mine -	50, 51	81 N.E.	99	
Red Seats Vein -	50	81 N.E.	99	
Slitherstone Mines -	51	81 N.E.	99	
Watt's Groove (or Grove) Vein.	51, 52	81 N.E.	99	
Bradwell.				
Bradwell Mines -	52	81 N.E.	99	
Chapmaiden Rake -	53	81 N.E.	99	
Cop Mines - -	52	81 N.E.	99	
„ Rake - -	52	81 N.E.	99	
Earl (or Ell or Hill) Rake.	53	81 N.E.	99	
Intake Dale Mines -	53	81 N.E.	99	
Milldam Mine - -	52	81 N.E.	99	
Moss Rake - -	52, 53	81 N.E.	99	

Name.	Pages on which reference is made in the Memoir.	One-inch Maps.		Six-inch Geological maps.
		Old Series Geological.	New Series Ordnance.	
DERBYSHIRE—*continued.*				
Rake Head Mine -	52	81 N.E.	99	
Scrin Rake -	53	81 N.E.	99	
Shuttle Rake - -	53	81 N.E.	99	
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* Published geological map, colour-printed.

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